International Journal of High-Energy Physics

CERN COURIER

Volume 47 Number 8 October 2007

Astronomy comes to the Atacama

W-IE-NE-R Plein & Baus GmbH
proudly presents

NEMBOX

Nuclear Electronics Miniature Box
Now available in NIM format
(NIMbox)

NIMbox is a series of programmable NIM modules (FPGA based) which offers a wide range of functions

- **USB access** on the rear side
- LABview VIs
- Programmable logic (AND, OR…)
- Discriminators
- ADC, DAC
- Scaler, pulser
- TDC
- Gate generation

Examples of applications

- Complex trigger logic
- Multiplicity trigger
- NIM/TTL/NIM converter
- Oscilloscope / Pulser
- Discriminators / Trigger / DAQ all at once
- Data acquisition via USB

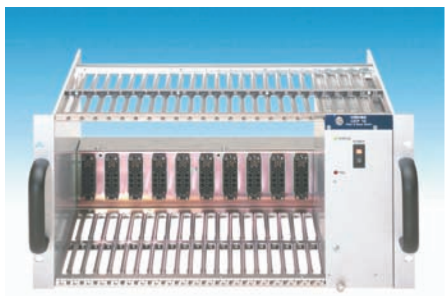
NPL20 **NAD4** **NDL8** **NDA4**

NPL20 – 20 channel NIM programmable logic
NAD4 – 4 channel 100 MHz 14 bit ADC with 8 TTL I/O ports
NDL8 – 8 channel leading edge discriminator with logic
NDA4 – 4 channel 125 MHz 14 bit DAC with 8 TTL I/O ports

… and more

NIMbox can be operated in Wiener low cost NIM crates.

Please contact Wiener for more information



www.wiener-d.com

In collaboration with University of Heidelberg

Plein & Baus GmbH, Muellersbaum 20, 51399 Burscheid, Germany
Phone: (+49 2174) 6780, Fax: (+49 2174) 678 55

W-IE-NE-R Plein & Baus Elektronik
Werk für Industrie-elektronik
Nuklear-elektronik
Regelungs-technik

Covering current developments in high-energy physics and related fields worldwide

CERN Courier is distributed to member-state governments, institutes and laboratories affiliated with CERN, and to their personnel. It is published monthly, except for January and August. The views expressed are not necessarily those of the CERN management.

Editor Christine Sutton
CERN, 1211 Geneva 23, Switzerland
E-mail cern.courier@cern.ch
Fax +41 (0) 22 785 0247
Web cerncourier.com

Advisory board James Gillies, Rolf Landua and Maximilian Metzger

Laboratory correspondents:
Argonne National Laboratory (US) Cosmas Zachos
Brookhaven National Laboratory (US) P Yamin
Cornell University (US) D G Cassel
DESY Laboratory (Germany) Ilka Flegel, Ute Wilhelmsen
EMFCSC (Italy) Anna Cavallini
Enrico Fermi Centre (Italy) Guido Piragino
Fermi National Accelerator Laboratory (US) Judy Jackson
Forschungszentrum Jülich (Germany) Markus Buescher
GSI Darmstadt (Germany) I Peter
IHEP, Beijing (China) Tongzhou Xu
IHEP, Serpukhov (Russia) Yu Ryabov
INFN (Italy) Barbara Gallavotti
Jefferson Laboratory (US) Steven Corneliussen
JINR Dubna (Russia) B Starchenko
KEK National Laboratory (Japan) Youhei Morita
Lawrence Berkeley Laboratory (US) Spencer Klein
Los Alamos National Laboratory (US) C Hoffmann
NIKHEF Laboratory (Netherlands) Paul de Jong
Novosibirsk Institute (Russia) S Eidelman
NCSL (US) Geoff Koch
Orsay Laboratory (France) Anne-Marie Lutz
PSI Laboratory (Switzerland) P-R Kettle
Saclay Laboratory (France) Elisabeth Locci
Science and Technology Facilities Council (UK) Peter Barratt

Produced for CERN by IOP Publishing Ltd
IOP Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK
Tel +44 (0)117 929 7481

Publisher Joseph Tennant
Art director Andrew Giaquinto
Senior production editor Jonathan Cailes
Production editor Lizi Brown, Jesse Karjalainen
Technical illustrator Alison Tovey
Advertising manager Ed Jost
Recruitment advertisement manager Moo Ali
Recruitment and classified sales Adam Hylands and Sonia Nardo
Recruitment and classified sales North America Mark Gaglione
Advertisement production Jayne Boulton
Marketing executive Chinh Dinh

Advertising
Tel +44 (0)117 930 1026 (for UK/Europe display advertising), +1 215 627 0880 (for North American display advertising), or +44 (0)117 930 1196 (for recruitment advertising); e-mail sales@cerncourier.com; fax +44 (0)117 930 1178

General distribution Courrier Adressage, CERN, 1211 Geneva 23, Switzerland. E-mail courrier-adressage@cern.ch
In certain countries, to request copies or to make address changes, contact:
China Keqing Ma, Library, Institute of High Energy Physics, PO Box 918, Beijing 100049, People's Republic of China. E-mail keqingma@mail.ihep.ac.cn
Germany Veronika Werschner, DESY, Notkestr. 85, 22607 Hamburg, Germany. E-mail desypr@desy.de
Italy Loredana Rum or Anna Pennacchietti, INFN, Casella Postale 56, 00044 Frascati, Rome, Italy. E-mail loredana.rum@inf.it
UK Mark Swaisland, Chadwick Library, Daresbury Laboratory, Daresbury, Warrington, Cheshire WA4 4AD, UK. E-mail m.r.swaisland@dl.ac.uk
US/Canada Published by Cern Courier, 6N246 Willow Drive, St Charles, IL 60175, US. Periodical postage paid in St Charles, IL, US. Fax 630 377 1569. E-mail vosses@aol.com
POSTMASTER: send address changes to: Creative Mailing Services, PO Box 1147, St Charles, IL 60174, US

Published by European Organization for Nuclear Research, CERN, 1211 Geneva 23, Switzerland. Tel +41 (0) 22 767 61 11
Telefax +41 (0) 22 767 65 55

Printed by Warners (Midlands) plc, Bourne, Lincolnshire, UK

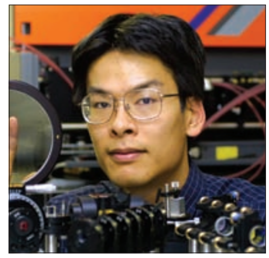
IOP Publishing

CERN COURIER

VOLUME 47 NUMBER 8 OCTOBER 2007

Charming Slovakia p15

Picture-perfect at the LHC p27



Spotting young talent p38

Cover: High in the Atacama desert, preparations have begun for a new large-scale radio telescope (p27). (Courtesy Mike Struik.)

STORAGE RINGS

First phase of BEPCII complete

The first phase of commissioning BEPCII, the major upgrade of the Beijing Electron–Positron Collider (BEPC) came to a successful conclusion on 3 August, when the beam current reached 500 mA at 1.89 GeV. On the same day the researchers also completed mapping the combined magnetic field of the superconducting insertion magnets (SCQs) and the superconducting solenoid of the detector BESIII. This followed a series of studies that included the first collisions between beams in the electron and positron rings. The successful commissioning of the superconducting magnets and the cryogenics demonstrated that both systems were stable and up to design performance.

BEPCII consists of two storage rings, with a new ring built inside the original BEPC ring at the Institute of High Energy Physics, Beijing. The installation of all of the storage ring components, except for the SCQs, finished in early November 2006. Phase I commissioning, based on the conventional magnets in the interaction region, started on 13 November and the first electron beam was stored in the outer ring on 18 November (*CERN Courier* January/February 2007 p7). The ring provided beams to the users of the Beijing synchrotron radiation facility for more than a month, from 25 December.

Commissioning both the electron and positron rings began in February 2007, and the first beam–beam collision occurred on 25 March. Optimization of the beam parameters followed, and on 14 May collisions occurred between beams of 100 mA each and 20 bunches per beam. The luminosity estimated from the measured beam–beam parameters reached a level comparable to that of the original BEPC, i.e. 10^{31} cm^{-2}s^{-1} at the beam energy of 1.89 GeV. A second round of synchrotron radiation (SR) operation followed from 15 June to 31 July, with a beam current of about 200 mA and a lifetime of 6–7 hours. A slow orbit correction led to orbit ripples of less than 10 μm (figure 1).

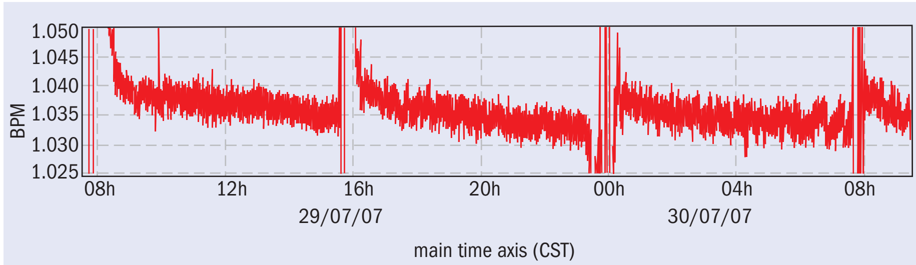


Fig. 1. A plot of beam-orbit stability measured with beam-position monitors (BPM).

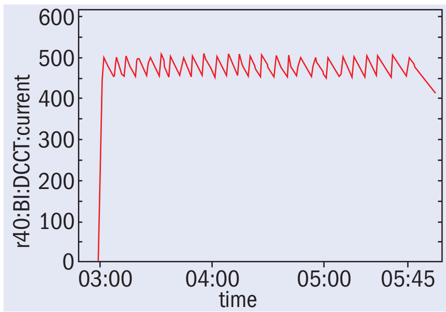


Fig. 2. Stable operation with 500 mA top-up injection at 1.89 GeV on 3 August.

Conventional magnets at BEPCII's interaction region. (Courtesy IHEP, Beijing).

Machine studies immediately followed the SR operation. With a bias-voltage applied to the radio-frequency coupler, the power provided by the superconducting cavity exceeded 100 kW and the beam current reached the design value of 250 mA at 2.5 GeV in SR mode. At the same time the beam current reached a stable 500 mA at 1.89 GeV without feedback (figure 2). The smooth commissioning demonstrated the good performance of the BEPCII hardware.

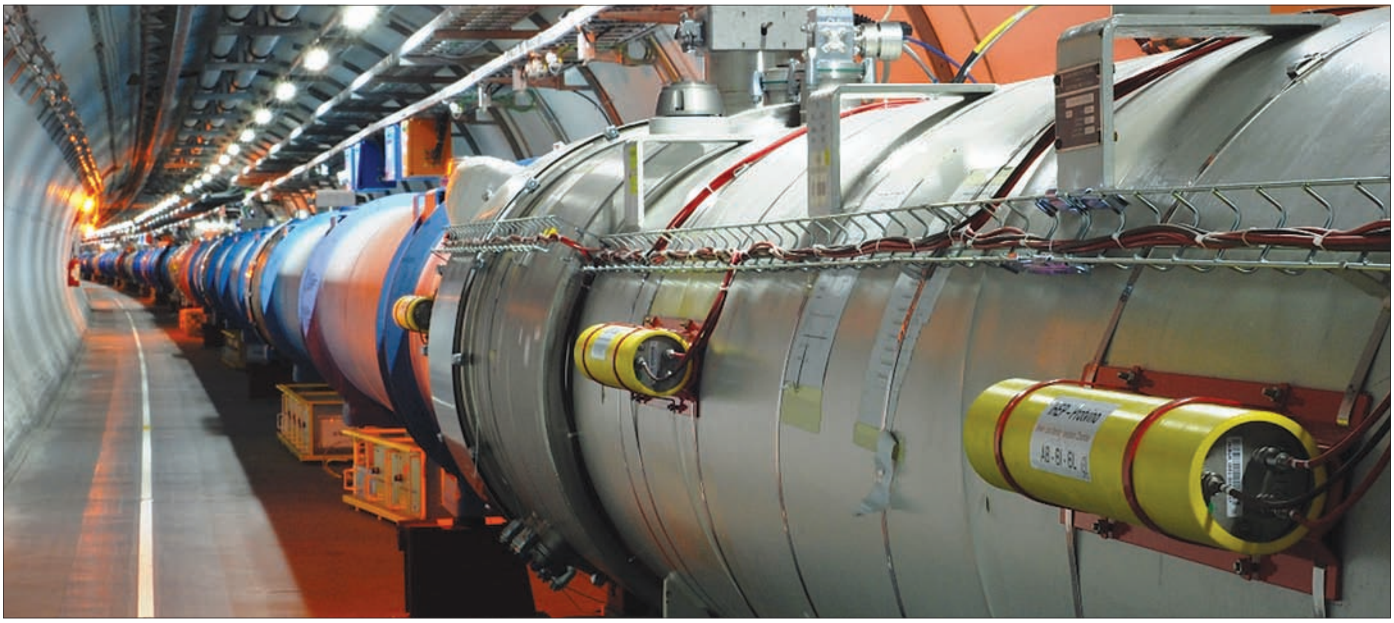
The construction of the BESIII detector has been smoothly progressing simultaneously. The assembly and testing of most of the sub-detectors, including the electromagnetic calorimeter barrel (CsI crystals) and the drift chamber, are now finished and ready for integration in BESIII.

After the Phase I commissioning, BEPCII shut down until the end of September for maintenance and the installation of the new interaction region components. Commissioning will resume in early October with the SCQs – and BESIII should be ready to be transported into the interaction region in the spring next year.

Sommaire

LHC NEWS

IHEP and CERN collaborate well on beam-loss monitors



Beam-loss monitoring ionization chambers (the yellow tubes on the red supports) mounted on an LHC quadrupole magnet.

The circulating beams will store an unprecedented amount of energy when the LHC is in operation. If even a small fraction of this beam deviates from the correct orbit, it may induce a quench in the superconducting magnets or even cause physical damage to system components. The LHC beam-loss monitoring (BLM) system is the key to protecting the machine against dangerous beam "losses" of this kind.

The BLM system generates a beam abort trigger when the measured rate of lost beam exceeds pre-determined safety thresholds. The lost beam particles initiate hadronic showers through the magnets, which are measured by monitors installed outside of the cryostat around each quadrupole magnet. About 4000 BLMs – mainly ionization chambers – will be installed around the LHC ring. They are the result of a successful collaboration between CERN and the Institute for High Energy Physics (IHEP) in Protvino, Russia. CERN developed the monitors and IHEP manufactured them during the past year, using industry-produced components.

Signal speed and robustness against aging were the main design criteria. The monitors are about 60 cm long with a diameter of 9 cm and a sensitive volume of 1.5 l. Each one contains 61 parallel aluminium electrode plates separated by 0.5 cm and is filled with nitrogen at 100 mbar overpressure and permanently sealed inside a stainless-steel cylinder. They operate at 1.5 kV and are equipped with a low-pass filter at the high-voltage input. The collection time of the electrons and ions is 300 ns and 80 μs, respectively.

The radiation dose on the detectors over 20 years of LHC operation is estimated at 2×10^8 Gy in the collimation sections and 2×10^4 Gy at the other locations. To avoid radiation aging, production of the chamber components included a strict ultra-high vacuum (UHV) cleaning procedure. As a result, impurity levels from thermal and radiation-induced desorption should remain in the range of parts per million. Standardized test samples analysed at CERN periodically helped to check the cleaning performance.

The team at IHEP designed and built a special UHV stand to ensure suitable conditions for building the monitors. They performed checks throughout the production phase and documented the results. The quality of the welding is a critical aspect, so the team tested all of the welds for leak tightness at several stages. They also monitored constantly the vacuum and the purity of the filling gas. It was necessary to test the components before welding, and the assembled monitors during and after production, to ensure that the leakage current of the monitors stayed below 1 pA. Overall, IHEP achieved a consistently high quality for the monitors during the whole production period and kept to the tight production schedule. Tests at CERN's Gamma Irradiation Facility of all 4250 monitors found fewer than 1% to be outside of the strict tolerance levels.

HEAVY IONS

RHIC glimpses process that could limit LHC

Measurements at RHIC at Brookhaven National Laboratory (BNL) have provided the first observations at a particle collider of a long-anticipated physical process that may eventually limit the performance of the LHC at CERN. Known as bound-free pair production, the process leads to the formation of one-electron ions that stray out of the beam and might deposit enough energy to quench the LHC's superconducting magnets. It is thus vitally important to estimate the effect at the LHC.

RHIC typically collides gold nuclei at an energy of 19.7 TeV (100 GeV/nucleon) and, in its heavy-ion programme, the LHC will collide lead nuclei at 574 TeV (2759 GeV/nucleon). The main aim in these heavy-ion collisions is to "melt" the constituent protons and neutrons of the nuclei into a plasma of strongly interacting quarks and gluons. However, heavy-ion collisions also provide access to electromagnetic forces of phenomenal intensity, as relativistic length contraction dramatically squashes the electric field lines emerging from each highly charged nucleus into a flat pancake shape. When these "pancakes" interact, large numbers of electron–positron pairs are ripped out of the vacuum. In some cases, the electron of the pair is attached to one or other nucleus, converting a small fraction of the beam to one-electron ions. These soon stray from the path of the main beam and are lost in a well-defined patch of the beam-pipe surface.

The beam loss initiates a shower of particles (hadrons) that cause localized heating. At RHIC, the rate and energy of the collisions and the field in the magnets are all low enough that there is no danger of the magnets quenching. At the LHC, however, the heating will be several thousand times greater (up to 25 W) and researchers predict that the process will be a direct limit on the luminosity of lead-ion collisions. The LHC calculations depend not only on the theoretical cross-section but also tracking of ions to their impact points, the development of the hadronic showers, the propensity of the magnets to quench and the response of beam-loss monitors outside of the cryostats.

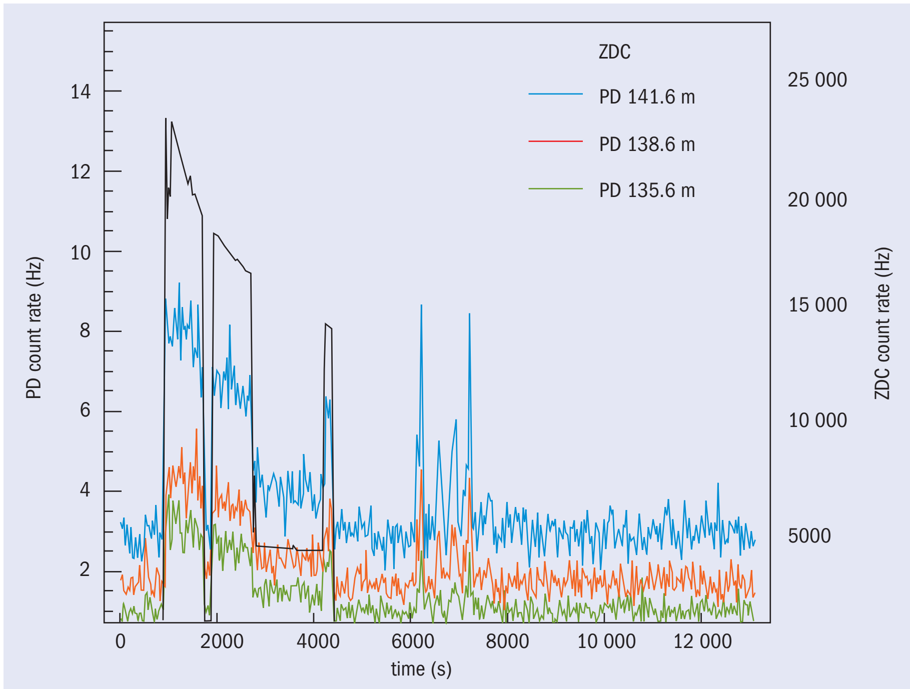


Fig. 4. Count rates measured on luminosity monitors (black plot, right scale) and the three photodiodes with the highest signal (coloured plots, left scale), showing a clear correlation between the luminosity and the photodiode count rates.

A team from CERN, BNL and Lawrence Berkeley National Laboratory has now measured this process for the first time, using beams of 6.3 TeV copper nuclei at RHIC and an array of photodiodes to detect the showers (Bruce *et al.* 2007). The team mounted the diodes on the outside of the magnet cryostat downstream from the interaction region for one of the experiments (PHENIX).

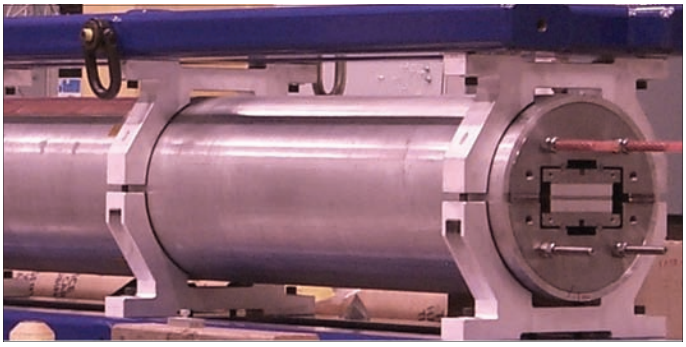
The data correlated well in time with the measured luminosity in RHIC, and were localized in position, close to the predicted impact point. The count rates in the photodiodes varied from 1 to 20 Hz, depending on their position and luminosity, with the maximum at 140.5 m from the interaction point. The results agree reasonably well with predictions, validating the LHC methodology and confirming the order of magnitude of the theoretical cross-section.

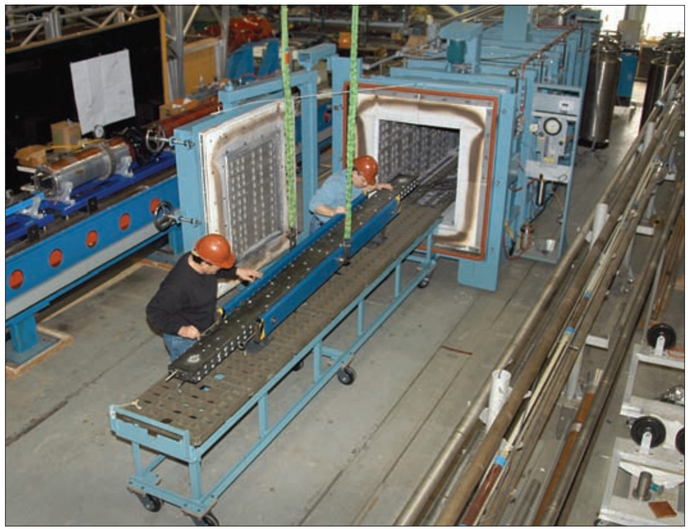
Further reading

R Bruce *et al.* http://arxiv.org/pdf/0706.2292, to be published in *Phys. Rev. Letts*.

MAGNET TECHNOLOGY

Major milestone for 'mighty magnet' as it goes the distance





Above: the support structure of the first long racetrack shell (LRS) magnet. The LHC, when it is upgraded, could receive superconducting quadrupoles based on these prototype magnets. (Courtesy Paolo Ferracin, Lawrence Berkeley National Laboratory.) Right: one coil of the LRS magnet being moved into the reaction oven at Brookhaven National Laboratory (BNL). (Courtesy BNL.)

The LHC is not yet up and running, but already physicists and engineers in Europe, Japan and the US are working towards upgrades for the machine. In the US, the LHC Accelerator Research Programme (LARP) reached a major milestone in July when Brookhaven National Laboratory (BNL) successfully tested the first long racetrack shell (LRS) magnet, named because of its shape. The LRS magnet is a precursor of an upgraded superconducting quadrupole planned for the LHC.

The US group is working on strategies to upgrade the inner triplet quadrupole magnets that perform the final focusing of the particle beams prior to collision. These magnets are close to the interaction points, so they must be built to withstand high doses of radiation. An upgraded, higher-luminosity LHC will mean a hotter environment for these magnets.

Because upgraded inner triplets will need to operate at both a higher temperature and magnetic field, the US team, from BNL, Fermilab and Lawrence Berkeley National Laboratory, is evaluating niobium-tin (Nb_3Sn) technology for the magnet coils, rather than the well-established niobium-titanium that is used in the current LHC magnets. However, the material is difficult to work with. The Next European Dipole research activity is also investigating Nb_3Sn conductors for use in upgraded LHC magnets as part of the Coordinated Accelerator Research in Europe programme.

The LRS magnet is the first accelerator-style Nb_3Sn magnet to be fabricated significantly longer than 1 m. At 3.6 m long, it approaches the length that will be needed for the LHC. BNL fabricated the coils for the LRS, and LBNL designed and fabricated the support structure. Fermilab contributed project management, conductor characterization, insulation development and insulated cable for a practice coil.

The first of these magnets, LRS01, was tested in July at BNL. "Training" the magnet (or subjecting it to repeated quenches) started above 80% of what is estimated to be the magnet's maximum current density of 10.6 kA. After five quenches, the current reached 91% of the estimated maximum, corresponding to a coil peak field of 11 T.

The LRS01 magnet provides key information on the fabrication of long Nb_3Sn and the optimization of shell-based support structures. The next step for LARP will be to build the Long Quadrupole. This will be the first-ever 4 m-long Nb_3Sn accelerator-type magnet of its kind.

Les physiciens des particules du monde entier sont invités à apporter leurs contributions aux *CERN Courier*, en français ou en anglais. Les articles retenus seront publiés dans la langue d'origine. Si vous souhaitez proposer un article, faites part de vos suggestions à la rédaction à l'adresse cern.courier@cern.ch.

***CERN Courier* welcomes contributions from the international particle-physics community. These can be written in English or French, and will be published in the same language. If you have a suggestion for an article, please send your proposal to the editor at cern.courier@cern.ch.**

ASTROPARTICLE PHYSICS

The LOFAR radio telescope detects its first pulsar

Using its first station of distributed radio antennas, the Low Frequency Array (LOFAR) radio telescope has successfully detected the pulsar PSR B0329+54. The measurement took 15 minutes on 14 June and used only six of the prototype high-band antennas recently installed in the eastern part of the Netherlands. The results demonstrate the technical performance of the antennas.

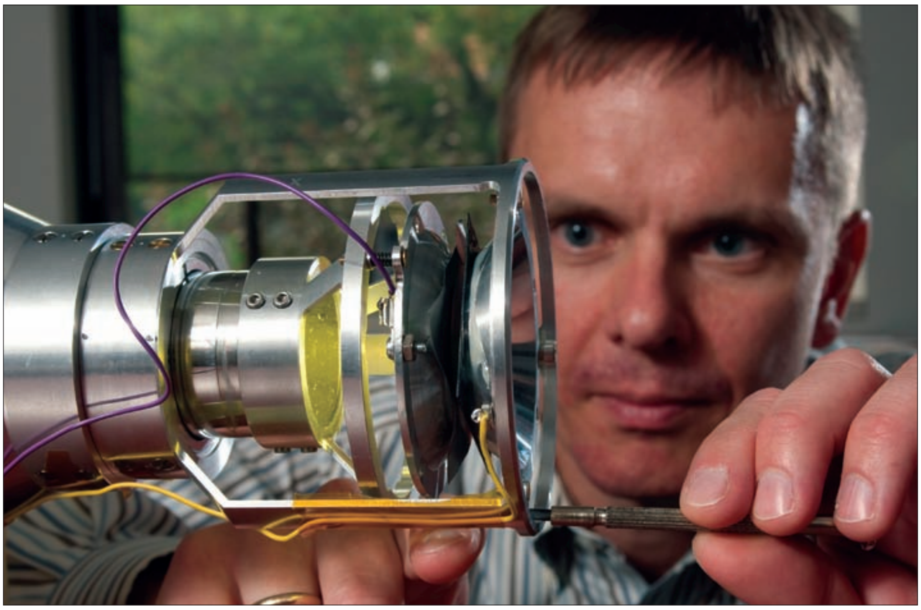
LOFAR will be the largest radio telescope ever built, using a new concept based on a vast array of simple omni-directional antennas. The idea is to digitize the signals before sending them to a central digital processor where software will combine them to create the effect of a large conventional antenna. When finished, it will consist of 15 000 small antennas, distributed to more than 77 stations in the north east of the Netherlands and nearby parts of Germany. The array will operate at the lowest frequencies that can be observed from Earth, at 10–240 MHz. Plans exist for the extension of the array beyond its initial 100 km scale, by building stations further into Germany and also in the UK, France, Sweden, Poland and Italy.

One important area of research, in addition to more conventional astronomy, will be the detection of extensive air showers originating from high-energy cosmic rays, and perhaps even neutrinos. Researchers have known since the 1960s that these showers produce radio signals that are detectable for cosmic-ray energies above 10^{17} eV. The radio emission comes from charged particles in the shower, mainly electrons and positrons, which are deflected in the Earth's magnetic field and produce coherent synchrotron radiation. Electronic devices in the 1960s were not sensitive enough for reliable measurements of the radio emission. However, researchers have now developed new observational techniques and radio receiver systems – such as those that LOFAR employs. Through its observations, LOFAR should be able to study the longitudinal development of air showers and reconstruct the original directions of the incident cosmic rays.

Two other European experiments – CODALEMA in France, and LOPES in Germany – have already confirmed that radio detection techniques can be used to observe extensive air showers induced by cosmic rays (*CERN Courier* April 2007 p33). In addition, the Auger collaboration in Argentina is testing the same technique, with plans to implement a large array of antennas in conjunction with the existing air-Cherenkov detectors.

NUCLEAR PHYSICS

Fast fragmentation produces double firsts for exotic nuclei



Krzysztof Starosta of the National Superconducting Cyclotron Laboratory adjusts the plunger device, which can make in-flight distance measurements at the sub-micron scale.

The three-storey S800 spectrograph separates and identifies isotopes after the secondary collision with very high resolution. (Photos courtesy NSCL.)

Researchers at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University have made new observations in different regions of the isotopic landscape by examining the nuclear structure of ^{64}Ge and ^{36}Mg.

Nuclei with equal proton (Z) and neutron (N) numbers are important in unravelling nuclear structure, in particular in the context of the shell model (see p31). Between ^{56}Ni and ^{100}Sn they exhibit a variety of shapes, evolving from spherical to prolate (cigar-shaped) to oblate (pancake-shaped) as the mass increases. Studies of transition rates between excited states and ground states in these nuclei provide important information to test shell-model predictions.

One such experiment at NSCL has studied ^{64}Ge (N=Z=32), making use of the recoil distance method (RDM) to measure the lifetime of two excited states (Starosta *et al*. 2007.) This was only the second measurement of this kind conducted in this region of isotopes, and the first to use the RDM at a fast-fragmentation facility. The beam speed at NSCL, 10 times higher than in previous RDM studies, allows for greater precision and gives access to a range of previously unattainable isotopes.

The experiment used a variety of state-of-the-art techniques, including a plunger device developed at the University of Cologne for use with the RDM. The plunger device produced the ^{64}Ge nuclei in reactions where a single neutron was knocked out of incident ^{65}Ge nuclei in a beam that contained a mixture of rare isotopes. The RDM used high-resolution gamma-ray spectroscopy and the Doppler effect to determine the lifetime of the excited states. The results agree well with large-scale shell-model calculations for the two excited states studied, and show the promise of the techniques used.

Exotic nuclei far from N=Z, with too many neutrons, offer other possibilities for testing shell-model predictions. One area of interest is the "island of inversion" where around a dozen neutron-rich isotopes should exhibit shell orderings that differ from standard theoretical predictions.

Studies of magnesium isotopes have already placed $^{31-34}$Mg (Z=12, N=19–22) in the island. Now, for the first time, an experiment at NCSL has examined the shell structure of ^{36}Mg which has as many as 24 neutrons (Gade *et al*. 2007). In this case, a secondary beam of ^{38}Si collided with a beryllium target to create ^{36}Mg on rare occasions: only 1 in 400 000 ^{38}Si nuclei yielded the desired ^{36}Mg. Spectroscopic measurements of the first excited state confirmed shell-model predictions, placing ^{36}Mg in the island of inversion as expected.

Further reading

K Starosta *et al*. 2007 *Phys. Rev. Lett.* **99** 042503.

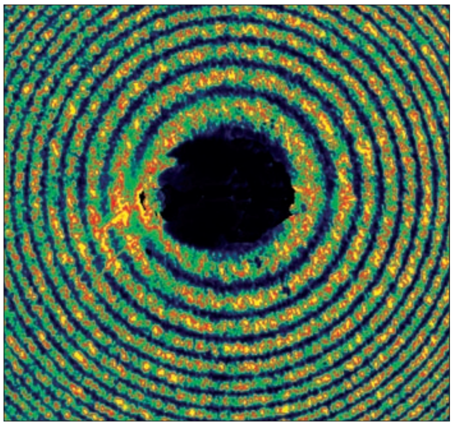
A Gade *et al*. 2007 *Phys. Rev. Lett.* **99** 072502.

Compiled by Steve Reucroft and John Swain, Northeastern University

Mirror dust inspires X-ray studies

In one of his experiments, Isaac Newton observed rings of light coming from a pinhole source reflected by a dusty mirror. Amazingly, it turns out that this could hold the key to X-ray imaging of nanoscale and biological processes. What Newton saw was due to the interference of light scattered twice by dust; once before and once after reflection by the mirror. Now, Henry Chapman and colleagues at Lawrence Livermore National Laboratory (LLNL) have applied the same sort of effect to form images of the explosions of tiny polystyrene spheres that are only 140 nm in diameter, on a timescale of 500 fs with a time resolution as small as 1 fs.

The technique is vastly simpler than any other that can provide this sort of time resolution. The researchers, working at the FLASH soft-X-ray free-electron laser at DESY, used a laser pulse to make a sphere explode, and then directed the same laser pulse back at the sphere after reflecting it from an X-ray "mirror". The interference pattern between the light scattered on the two occasions formed a hologram containing information about changes occurring in the sphere during the time that it took for the laser pulse to be reflected.



A typical interference pattern as formed by Chapman and colleagues using a laser pulse. The pattern encodes the shape and evolution of the object. (Courtesy LLNL.)

The researchers predict that, with upcoming ultrafast X-ray sources, the technique will allow them to explore the three-dimensional dynamics of materials at the timescale of atomic motion.

Further reading

H N Chapman *et al.* 2007 *Nature* **448** 676.

New 'out of body' perspective

So called "out of body experiences" are not usually treated as relatively respectable fields of research. However, two groups have now reported novel ways of inducing them under controllable conditions, so opening up the field to proper scientific study.

Bigna Lenggenhager of the École Polytechnique Fédérale de Lausanne and colleagues, and H Henrik Ehrsson of the Wellcome Trust Centre for Neuroimaging in London and the Karolinska Institute in Stockholm reported similar findings in the same issue of *Science.* They found in independent experiments that people using head-mounted VDUs to see themselves from unusual perspectives could be induced to feel and experience things as if they had their bodies in places where they physically were not. Is this a case of virtual unreality?

Further reading

B Lenggenhager *et al.* 2007 *Science* **317** 1096.

H H Ehrsson 2007 *Science* **317** 1048.

Towards a cableless future

The last cable that seems indispensable for most electronic devices is the power cable. But André Kurs of Massachusetts Institute of Technology and colleagues have demonstrated the wireless transfer of 60 W over 2 m at 40% efficiency using strongly coupled magnetic resonance in a resonant transformer with the primary and secondary windings widely separated.

The team used two identical helical coils with a radius of 30 cm and 20 cm high wound from more than five turns of copper. With both coils on resonance, they powered a 60 W light bulb from more than 2 m away. Calculations indicate that electromagnetic radiation is low and electric fields are small, minimizing potential biological effects. The cumbersome power cable may soon be a thing of the past.

Further reading

A Kurs *et al.* 2007 *Science* **317** 83.

Seeing through an opaque lens

Lenses are normally thought of as being transparent, but this assumption has been turned on its head by the recent work of I M Vellekoop and A P Mosk of Twente University in the Netherlands. Their idea is simple: light that goes through things like eggshells, layers of white paint or even human tissue, is scattered wildly as it passes through. But, if the incoming light is specially prepared to have a wavefront of an appropriate shape, this random scattering can be translated into focusing.

The researchers claim that the wavefront construction can be done with an array of liquid crystals modulating the phase in light from a helium-neon laser. They passed this prepared light through an opaque sample of titanium oxide and found that they could bring it into focus on a CCD camera. The results show that the technique can lead to focusing equivalent to the best optical microscope, even though the material used appears to be an opaque random scatterer.

Further reading

I M Vellekoop and A P Mosk 2007 *Optics Letters* **32** 2309.

Compiled by Marc Türler, INTEGRAL Science Data Centre and Observatory of Geneva University

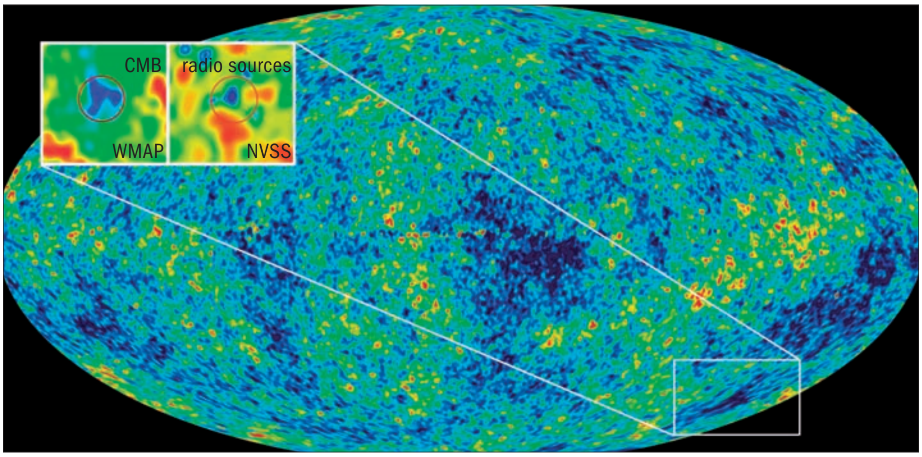
WMAP's cold spot shows giant void in space

An enormous void, nearly a thousand million light-years across, seems to be at the origin of a cold spot that the Wilkinson microwave anisotropy probe (WMAP) has found in the cosmic microwave background (CMB). This region, largely empty of galaxies and dark matter, is much larger than voids observed or predicted using computer simulations.

The map of temperature fluctuations in the CMB as observed by WMAP shows a distinct feature known as the "cold spot". Some attempts to explain this peculiar feature have invoked non-Gaussian processes to alter the radiation when it was emitted about 400 000 years after the Big Bang. Alternatively, the observed radiation could also be modified on its journey of thousands of millions of years from the outer regions of the universe to the Earth.

For instance, a CMB photon can gain energy by "falling" into the potential well of a dense region, such as a cluster of galaxies. Normally, it should lose the same amount of energy again when moving out of this area. However, under the effect of dark energy the potential well becomes less deep with cosmic time and the energy loss of the photon will not balance its earlier energy gain completely. This subtle effect – known as the "late integrated Sachs–Wolfe effect" – would make a hot spot in the map of the CMB in the line of sight of a galaxy cluster. In the opposite case of an extended void in space, the net effect on the CMB map would produce a cold spot.

Is there something special about the distribution of galaxies in the direction of WMAP's cold spot? This is what Lawrence Rudnick from the University of Minnesota wondered. Investigations are based on the NVSS – the National Radio Astronomy Observatory (NRAO) Very Large Array (VLA) Sky Survey. The NVSS programme observed 82% of the sky visible from the VLA location in New Mexico from 1990 to 1997 and produced a catalogue of more than 1.8 million individual radio sources. By smoothing these observations to a resolution of a few degrees, Rudnick found a clear dip exactly at the position of the WMAP cold spot. Both the radio intensity and the number of radio sources are lower in this region of the river constellation Eridanus.



A zoom on the cold-spot region in the map of the cosmic microwave background (CMB) observed by the WMAP spacecraft. This illustrates the 25° region around the cold spot (left, with blue being coldest) and a heavily smoothed portion of the NRAO VLA Sky Survey (NVSS), showing the blended emission from radio galaxies along each path (right, blue indicates brightnesses approximately 20% below the average). (Courtesy NASA/WMAP Science Team and Rudnick et al. *NRAO/AUI/NSF.)*

As radio sources are good tracers of the presence of galaxies – and thus of mass in the universe – it makes sense to assume that the WMAP cold spot comes from this dip in the projected distribution of galaxies through the late integrated Sachs–Wolfe effect. Rudnick and colleagues estimate the size of the volume that would need to be almost empty of matter to explain the cold spot of WMAP through this effect. The result is a big void of almost a thousand million light-years in size, which should be located in the relatively nearby universe – at most, at a redshift of $z \sim 1$ – when the effect of dark energy starts to dominate the expansion rate of the universe (*CERN Courier* September 2003 p23). Such a big void exceeds by far the size of known regions of empty space and also the expectations of computer simulations of large-scale structures (*CERN Courier* September 2007 p11). Therefore, the WMAP cold spot remains a puzzle, no longer as a peculiarity of the very early universe but as an oddity of the time of structure formation.

Further reading

L Rudnick *et al.* in press *Astroph. Journal*. See also http://arxiv.org/abs/0704.0908.

Picture of the month

In July 2006, the Very Large Telescope of the European Southern Observatory took this picture of a supernova explosion in the beautiful spiral galaxy NGC 1288.

The supernova is the bright spot to the left of the galaxy centre located 200 million light-years away in the Fornax (the furnace) constellation. An amateur astronomer discovered the supernova, called SN 2006dr, on 17 July 2006. Follow-up observations by the Keck telescope found it to be a Type Ia supernova. Astronomers interpret such supernovae as the explosive disruption of a white-dwarf star accreting matter from a companion star. They act as standard candles and assist studies of the acceleration of the expansion of the universe (*CERN Courier* September 2003 p23). (Courtesy ESO.)

A look back to *CERN Courier* vol. 4 October 1964, compiled by Peggie Rimmer

POLICY

Weisskopf asks: why pure science?

Science is playing an ever-increasing role in our culture, our life and the economy of the world. Yet at the same time its results are becoming, for the layman, increasingly abstract and apparently further removed from everyday life. Astronomy is dealing with cosmic cataclysms billions of light-years away; physics with nuclear particles which exist only a billionth of a second; biology with macro-molecules containing billions of atoms ["billion" is used here in its American sense of a thousand million]. Meanwhile, the pursuit of pure science is becoming more and more expensive. Astronomers want huge new radio-telescopes to look at strange objects at the edge of the universe; probers of outer space want ever more expensive gadgets for the exploration of realms far removed from us; physicists want more money to find out more about the innermost structure of the atomic nucleus – and the citizen has a right to ask: why pure science?

When studying the development of industrial nations, one cannot fail to make the following observations: in the first half of the nineteenth century, England was the great industrial nation and, at the same time, produced the great names in fundamental research: Maxwell, Young, Faraday, etc. Then, in the second half of the 19th century and at the beginning of the 20th, Germany began to play a leading part. It is then that one finds a galaxy of German physicists: Helmholtz, Nernst, Rontgen, Planck, Sommerfeld, Heisenberg, etc. Later in the 20th century, as the US became the leading industrial nation, fundamental science blossomed in the US. Fermi, Oppenheimer, Lawrence, Rabi, McMillan, Alvarez, Schwinger, Feynman are only a few names illustrating this. There is a clear connection: where there is industrial growth there is basic science, and where there is basic science there is industrial growth.

The value of fundamental research does not lie only in the ideas it produces. If science is highly regarded and the importance of being concerned with the most up-to-date problems of fundamental research is recognized, then a spiritual climate is created which influences all other activities. An atmosphere of creativity is established which penetrates to every cultural frontier. Applied sciences and technology are forced to adjust themselves to the highest intellectual standards, which are determined in pure research; that is what attracts productive people and brings productive scientists to those countries where science is at its highest level.

Fundamental research creates the intellectual climate in which our modern civilization flourishes. It pumps the lifeblood of ideas and inventiveness not only into the technological laboratories and factories, but into every cultural activity of our time.

The case for generous support for pure and fundamental science is as simple as that. A small part only of a nation's total income is needed to keep fundamental research in full swing. It would be wrong to try to save a fraction of this small part if such savings weakened the most vital and active part of our intellectual life, the part which we all should regard with pride as one of the highest achievements of our century.

● Compiled from "Why pure science?" pp136–142. Based on a talk given by Victor Weisskopf in Brussels in April 1964 during the "Journées nationales des hautes energies", organized by the Institut interuniversitaire des sciences nucléaires and the Societé belge de physique.

This photograph underlines a point made in the talk by Professor Weisskopf: "High-energy physics aims directly at the most fundamental questions of the basic laws governing the structure of matter and the universe. It therefore must play an important role in the education of the new generation of scientists, who come to our universities in ever increasing numbers." It shows members of the team working with the Saclay/École Polytechnique (Paris) 81-cm liquid-hydrogen bubble chamber at the CERN PS. Giovanni Borreani, adjusting one of the controls, is visiting CERN from the University of Turin. Making notes on the table is Albert Werbrouck, a US physicist also from the University of Turin. In the centre is Adolf Minten, a CERN staff member formerly at the University of Bonn, and standing on the right is Philippe Briandet of the École Polytechnique, Paris.

COMPILER'S NOTE

JJ Thomson, who discovered the electron in 1897, was, unsurprisingly, an advocate of pure science, which he defined as "research made without any idea of application to industrial matters, but solely with the view of extending our knowledge of the laws of nature".

In this talk in 1964, Victor Weisskopf (CERN's director-general 1961–1965) reasoned that pure science should be publicly funded because it creates the intellectual climate in which our civilization flourishes. In 1997, Sir Chris Llewellyn Smith (director-general 1994–1998) argued that government funding for basic science is essential because the benefits, and hence the economic returns, are general and are not specific to individual products (see http://outreach.web.cern.ch/outreach/public/cern/open-99-011.pdf.)

Obviously these authors would be unlikely to put a case against pure science, but at a time when excessive flourishing of our civilization might lead to its demise, "the citizen" has a right to ask whether research "without any idea of application" is unequivocally defensible.

Strangeness, charm and beauty come to Slovakia

The latest results on strangeness, charm and beauty production in heavy-ion collisions and expectations for the LHC provided the focus of attention at SQM 2007 in Levoča, in north-eastern Slovakia. **Federico Antinori** and **Emanuele Quercigh** report.

The conference participants near the exquisite St James' church on Master Paul Square in Levoča. (Courtesy F Brincko, Levoča.)

The International Conference on Strangeness in Quark Matter, SQM 2007, took place on 24–29 June in the charming old town of Levoča, located in Spiš in north-eastern Slovakia. It was the 12th in a well-established series of topical conferences organized by the Institute of Experimental Physics of the Slovak Academy of Sciences in Košice, and it brought together experts in particle physics, nuclear physics and cosmology. More than 100 scientists from 20 countries took part this year, and the contributions covered a wide range of issues, from the bulk properties of the partonic matter created in nucleus–nucleus collisions, to the energy loss of fast partons traversing the medium, with a particular emphasis on the perspectives for the future.

The SQM series is currently dedicated to understanding what the production of strange – and also charm and beauty – particles can reveal about the hot and dense partonic matter formed in a high-energy nucleus–nucleus collision. It could perhaps more appropriately be called Strangeness, Charm and Beauty in Quark Matter. However, because of tradition, the original name has stuck. The extension to flavours heavier than strangeness has occurred naturally over the years as the high energies available at RHIC (and ▷

expected at the LHC) have turned charm- and beauty-flavoured particles into practical and promising probes for exploring QCD matter. On the experimental side, the challenge of detecting strange, charm and beauty particles is similar – although more difficult with charm and beau ty – as the complete identification of all of these types of particle relies on identifying their decay products and decay vertices. Hence the need for similar techniques with the three flavours, both for the apparatus (high-granularity vertex detectors) and for the analysis. The SQM conferences therefore provide an excellent forum for researchers in this field to exchange not only physics results, but also information on experimental techniques and analysis methods.

There were more than 70 theoretical and experimental contributions this year, including review talks and reports from all of the active experiments at Brookhaven's RHIC (BRAHMS, PHENIX, PHOBOS and STAR), at CERN's SPS (CERES, NA49, NA57 and NA60) and at GSI's heavy-ion synchrotron, SIS (FOPI). As the start-up of the LHC is just around the corner, more contributions than ever illustrated the plans for physics at future facilities. There were presentations on ALICE, the LHC experiment dedicated to heavy-ion physics, and the heavy-ion programmes for ATLAS and CMS and on the experiment on compressed baryonic matter (CBM) that is planned at the Facility for Antiproton and Ion Research at GSI.

The first day was devoted to a symposium where graduate students and post-doctorates had the opportunity to present their research results. Before the summary talks on the last day, a brief commemoration took place in honour of Maurice Jacob. He was a leader in the theory of high-energy hadron physics, a strong supporter of heavy-ion physics and a friend to many of us. He passed away on 2 May (*CERN Courier* July/August 2007 p39) and we are all sorry that he did not live to enjoy the LHC's results.

Hadronization and fragmentation

The bulk of the observed hadrons with low transverse momenta ($p_T < 2$ GeV/c) are produced from matter that seems to be well-equilibrated by the time it dresses up into hadrons. In other words, statistical hadronization models reproduce hadron yields and ratios well, and in terms of only a few fitted parameters, such as temperature and chemical potentials. A robust collective flow accompanies this equilibration. In non-central collisions, the spatial azimuthal asymmetry of the initial state transfers very efficiently to a momentum asymmetry of the final state (*CERN Courier* January/February 2006 p28 and March 2007 p19). In a hydrodynamical description, an "elliptic flow" of this kind – generated at the early stages of the expansion – gives access to the equation of state of partonic matter. The combination of hydrodynamics and statistical hadronization leads to a reasonable parameterization of the low-p_T hadronic spectra and elliptic flow.

Many of the theory presentations dealt with the understanding of relativistic hydrodynamics and of the quark matter equation of state. Among several new results on the experimental side, we note that the RHIC data on copper–copper collisions at 200 GeV show enhancements of the Λ, Ξ, anti-Λ, anti-Ξ and ϕ-meson with respect to proton–proton collisions. These enhancements are similar to those found (at a given number of participant nucleons) in gold–gold collisions at the same energy and in lead–lead collisions at the energies of CERN's SPS.

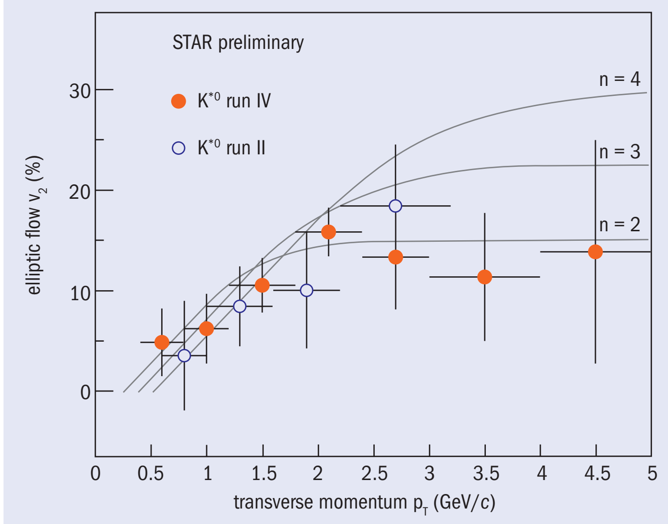


Fig. 1. Elliptic flow coefficent v_2 for the K meson as a function of its transverse momentum measured in Au–Au minimum biased collisions at 200 GeV per nucleon pair. The comparison with expectations (the curves) suggests that the K* is formed by combining a quark with an antiquark (n = 2 curve) in the partonic phase, instead of combining a pion and a kaon (n = 4 curve) in the subsequent hadronic phase.*

The presence of the medium appears to modify fragmentation functions, which describe the dressing up of partons into final state particles. At high p_T, the fragmentation of the parent parton is the dominating process. At intermediate p_T ($2 < p_T < 6$ GeV/c), however, the valence quark recombination or coalescence seems to play an important role. As a result, hadron production cannot be considered to be either thermal or perturbative, since the medium interferes with the hadronization process. For example, if hadrons are formed by recombination, the features of the parton spectrum are shifted to higher p_T in the hadron spectrum – and in a different way for mesons than for baryons.

In this context interesting new results on K* production were presented. The azimuthal asymmetry of these particles corresponds to that expected from the recombination of two valence quarks. This would occur if coalescence of a valence quark–antiquark pair forms the K*. This is in contrast to what would happen if the K* were produced in the hadronic phase by combining a K and a π, each formed from a valence quark–antiquark pair, therefore requiring the recombination of four valence quarks (figure 1).

Fast parton energy loss

Strong quenching of hadrons with large transverse momentum ($p_T > 6$ GeV/c) is another striking phenomenon, first observed at RHIC (*CERN Courier* January/February 2006 p25 and March 2007 p35). The high-p_T partons generated in hard scatterings at the initial stages of the nucleus–nucleus collisions do not fly away and hadronize freely. Instead, the nearby matter seems to largely absorb them. High-p_T photons instead remain essentially unaffected, leading to a picture of a dense medium that is opaque to partonic, coloured projectiles but relatively transparent to photons.

Vigorous theoretical and experimental efforts are under way to understand parton energy loss in terms of perturbative QCD

The conference excursion involved rafting on the river Dunajec between Slovakia and Poland. (Courtesy A Dirner, Košice.)

(pQCD). Various groups have described the suppression of light hadrons in terms of radiative energy loss by gluon bremsstrahlung. According to such calculations, charm and beauty quarks should be absorbed significantly less than light quarks and gluons. However, data from the PHENIX and STAR experiments, which compare the production in nucleus–nucleus and proton–proton collisions of high-p_T "non-photonic" electrons (thought to originate mainly in heavy-flavour decays), seem to indicate that heavy quarks lose energy as much as light quarks do.

There were many contributions devoted to this puzzle at SQM 2007. Attempts to reduce disagreement by including elastic-scattering losses in addition to the radiative ones are being considered. On the experimental side, participants stressed the need to separate out the fraction of electrons coming from the decay of beauty hadrons, since b quarks are expected to lose even less energy than c quarks. Another important experimental caveat concerns the distribution of heavy quarks among the different heavy-flavour hadron species. This could change when going from proton–proton to nucleus–nucleus collisions, leading to p_T-dependent variations of the semi-electronic branching ratios. Such an effect should obviously be kept under control when comparing electron production in nucleus–nucleus and proton–proton collisions. Some groups are making useful attempts in these directions by identifying the charmed meson D^0 from the reconstruction of its decay. However, vertex detectors such as those of the LHC experiments are necessary for pursuing these studies further.

The fate of the energy deposited by the partons along their path also turns out to be non-trivial. It appears as though the partons' propagation gives rise to some collective hydrodynamical motion. Among the contributions on this subject, there was an interesting study of the response of the medium to energy loss, by analysing two- and three-particle correlations. The results seem to indicate a peak in particle production on a cone at an angle of about one radian from the direction of the propagating parton. A possible explanation would be the generation of a shock wave in the medium. The answer to this and many other questions will probably have to wait for the LHC data. We hope that there will be some to discuss at the next two conferences in this series being held in Beijing (2008) and Rio de Janeiro (2009).

Further reading

More information about the conference, and the talks presented, are available at www.saske.sk/SQM2007.

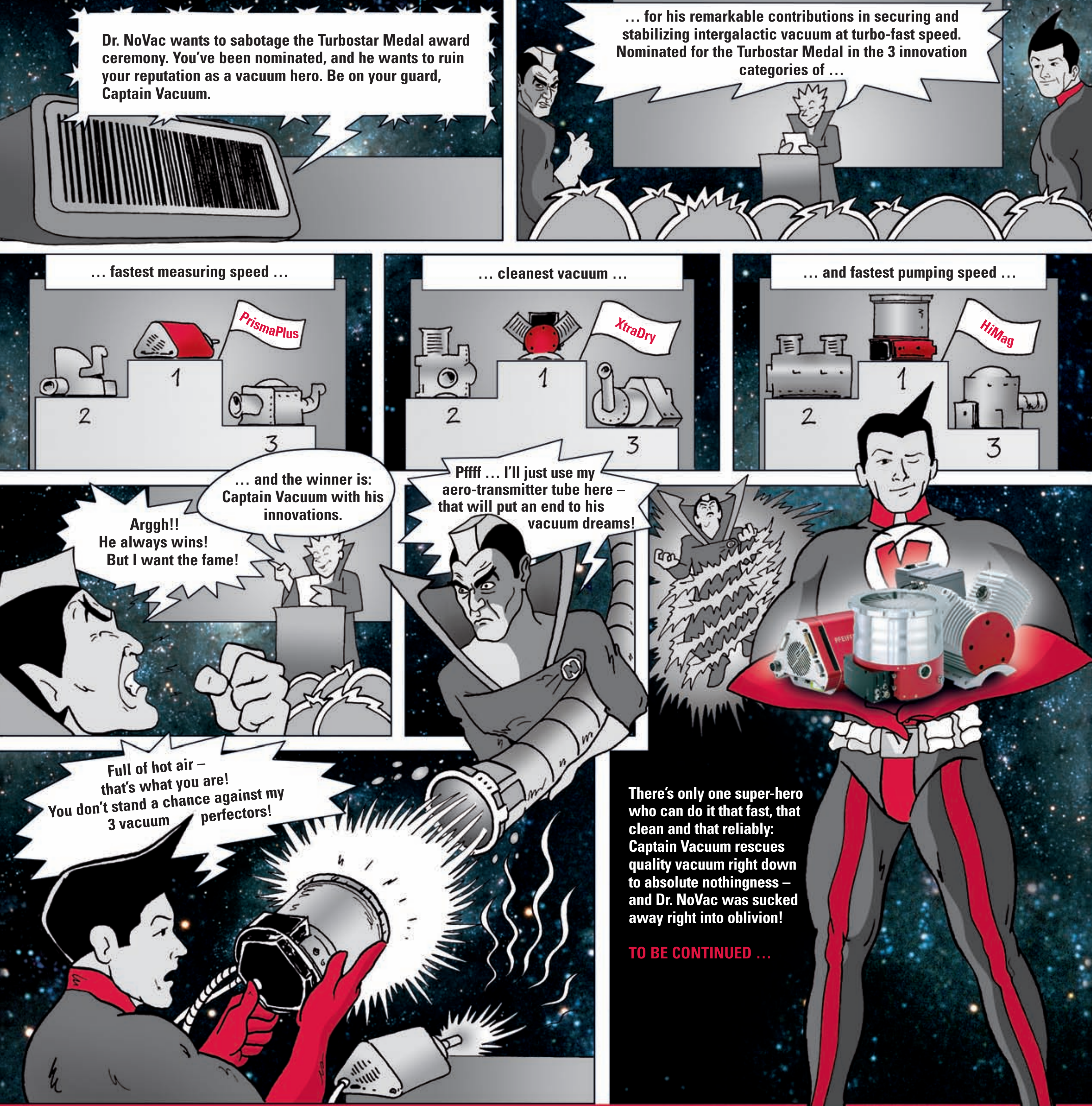
The Conference Proceedings will be published in *Journal of Physics G – Nuclear and Particle Physics*.

Résumé

L'étrangeté, le charme et la beauté ont rendez-vous en Slovaquie

Les derniers résultats sur la production d'étrangeté, de charme et de beauté dans les collisions d'ions lourds et les prédictions pour le LHC ont été au cœur de la conférence SQM 2007 à Levoča (Slovaquie). Plus de 100 scientifiques de 20 pays ont participé à cette douzième édition d'une série de conférences thématiques bien établies qui rassemblent des spécialistes de la physique des particules, de la physique nucléaire et de la cosmologie. Les contributions, très diverses, ont porté sur les propriétés générales de la matière partonique créée dans les collisions noyau–noyau ou la perte d'énergie des partons rapides lorsqu'ils traversent le milieu. Les perspectives pour l'avenir ont retenu toute l'attention.

Federico Antinori, *INFN Padova and CERN, and* **Emanuele Quercigh**, *CERN.*


Dr. NoVac wants to sabotage the Turbostar Medal award ceremony. You've been nominated, and he wants to ruin your reputation as a vacuum hero. Be on your guard, Captain Vacuum.
… for his remarkable contributions in securing and stabilizing intergalactic vacuum at turbo-fast speed. Nominated for the Turbostar Medal in the 3 innovation categories of …
… fastest measuring speed …
PrismaPlus
… cleanest vacuum …
XtraDry
… and fastest pumping speed …
HiMag
… and the winner is: Captain Vacuum with his innovations.
Arggh!! He always wins! But I want the fame!
Pffff … I'll just use my aero-transmitter tube here – that will put an end to his vacuum dreams!
Full of hot air – that's what you are! You don't stand a chance against my 3 vacuum perfectors!
There's only one super-hero who can do it that fast, that clean and that reliably: Captain Vacuum rescues quality vacuum right down to absolute nothingness – and Dr. NoVac was sucked away right into oblivion!
TO BE CONTINUED …

Exotic lead nuclei get into shape at ISOLDE

A research team at CERN's ISOLDE facility has uncovered the mainly spherical shape of exotic lead nuclei with too few neutrons by measuring the nuclear charge radii.

In nature, relatively few nuclei have a spherical shape in their ground state. Examples are ^{16}O, ^{40}Ca, ^{48}Ca and ^{208}Pb, which are "doubly magic", with numbers of both protons and neutrons corresponding to closed shells in the nuclear shell model (see p23). By moving away from the closed shells and increasing the number of valence nucleons, both protons and neutrons, these nuclei can eventually acquire a permanent deformation in their ground state. Experiments reveal that sometimes – due to the complex interplay of single-particle and collective degrees of freedom – both a spherical and deformed shape occur in the same nucleus at low excitation energies. In the region around lead, for example, physicists in the 1970s first observed this "shape co-existence", using optical spectroscopy at the ISOLDE facility at CERN (Bonn *et al.* 1972 and Dabkiewicz *et al.* 1979). Since then, an extensive amount of data has been collected throughout the chart of nuclei (Wood *et al.* 1992 and Julin *et al.* 2001).

Some of the best-known examples of shape co-existence are found in neutron-deficient lead nuclei (atomic number or number of protons, Z=82). The uniqueness of this region is mainly due to three effects. First, the energy gap of 3.9 MeV above the Z=82 closed proton shell forces the nuclei to adopt a spherical shape in their ground state. However, the energy difference is small enough for a second effect to occur: the creation of "extra" valence proton particles and holes as a result of proton-pair excitation across the gap. Third, a very large neutron valence space between the shell closures with the number of neutrons N=82 and 126 results in a large number of possible valence neutrons as nuclei approach the neutron mid-shell at N=104. The strong deformation-driving interaction between the "extra" valence protons and the valence neutrons produces unusually low-lying, deformed oblate (disc-like) and prolate (cigar-like) states in the vicinity of N=104, where the number of valence neutrons is maximal (Wood *et al.* 1992). In some cases, the deformation-driving effect is so strong that the deformed state becomes the ground state, as happens near N=104 in the light isotopes of mercury (Z=80) and platinum (Z=78).

Atomic spectroscopy provides direct and model-independent information on the properties of nuclear ground and isomeric states via a determination of hyperfine structure and the isotope shift. These are small effects on atomic energy levels due to the nuclear moments, masses, sizes and shapes of nuclear isotopes, allowing the spins, moments and changes in charge-radii of nuclei to be deduced. In particular, the changes in charge radii determined from the isotope shifts by optical spectroscopy in long isotopic chains have revealed collective nuclear properties clearly.

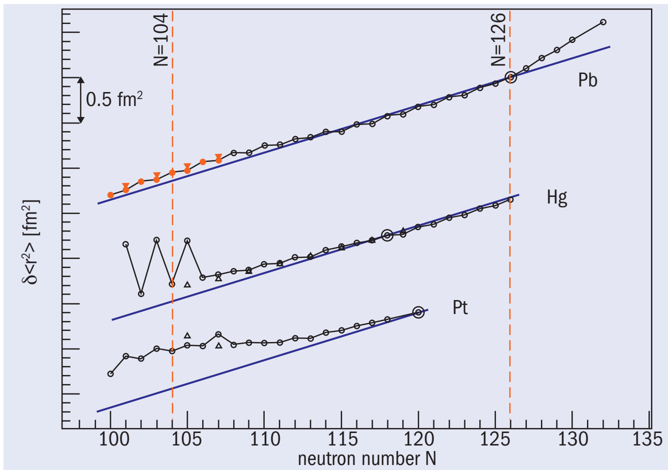
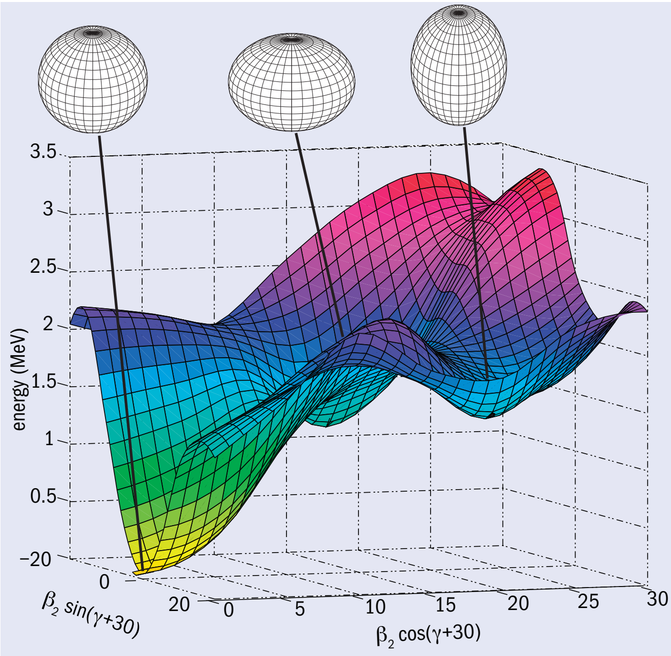


Fig. 1. Changes of mean-square charge radii for lead, mercury, and platinum isotopes. Circles show the ground states and triangles the isomeric states, the latest data are red. Solid lines indicate predictions of the spherical droplet model. (Changes are relative to a reference isotope circled for each element.)

Figure 1 shows changes of mean-square charge radii ($\delta<r^2>$) of lead, mercury and platinum isotopes as a function of the number of neutrons. All the data for the nuclides furthest from stability were determined at ISOLDE by a variety of techniques (Otten 1989 and Kluge and Nörtershäuser 2003). In the 1970s, nuclear-radiation detected optical pumping and laser fluorescence spectroscopy were used, collinear spectroscopy in the 1980s and resonance ionization mass spectroscopy from the late 1980s onwards. Now laser spectroscopy in the laser ion source is used, as described below.

Figure 1 shows how the measured $\delta<r^2>$ for platinum isotopes develop a distinct deviation from the smoothly decreasing trend expected from the spherical-droplet model. For mercury, a ▷



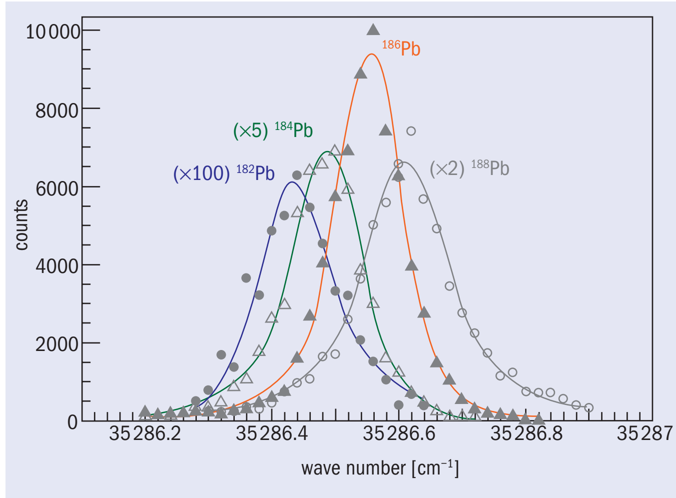


Fig. 2 (left). Potential energy surface for ^{186}Pb indicating the spherical, oblate and prolate minima (Andreyev et al. 2000). Fig. 3 (above). Alpha intensities versus wave number of the laser light used for the first excitation step for the even–even lead isotopes $^{182–188}$Pb (De Witte et al. 2007).

sudden and dramatic change in $\delta\langle r^2\rangle$ known as "shape staggering", occurs between ^{187}Hg and ^{185}Hg (N = 107 and 105 respectively). A similar change occurs between the isomeric (I = 13/2) and ground (I = 1/2) states in ^{185}Hg, in this case, "shape isomerism" or "shape co-existence" (Bonn *et al.* 1972 and Dabkiewicz *et al.* 1979). These effects are interpreted as a change from weakly deformed oblate to strongly deformed prolate shapes. The neutron-deficient lead isotopes are a particularly interesting example of shape co-existence. Theoretical calculations have long suggested the co-existence in these nuclei of three different shapes: spherical, prolate and oblate – hence triple co-existence. Recent particle (α, β) and in-beam studies have found strong evidence for this phenomenon in some of the isotopes from ^{182}Pb to ^{208}Pb.

One of the most spectacular examples is the mid-shell nucleus ^{186}Pb, as indicated in figure 2. Here, studies of the α-decay of the parent nucleus ^{190}Po have revealed a triplet of low-lying ($E^* < 650$ keV) 0^+ states (Andreyev *et al.* 2000). These were assigned to co-existing spherical, oblate and prolate shapes, with the spherical state being the ground state. Subsequent in-beam studies identified excited bands built on top of these states. An important question arises, however, concerning the degree of mixing between different configurations. As the excited 0^+ states decrease their energy when approaching N = 104 (^{186}Pb), their mixing with the 0^+ ground state could increase substantially, an effect that could possibly be seen in the value of the charge radii.

Therefore, the aim of experiment IS483 at ISOLDE was to measure for the first time the isotope shifts in the atomic spectra of the very neutron-deficient nuclei in the region ^{182}Pb to ^{190}Pb, deducing the mean-square charge radii in order to probe the ground state directly (De Witte *et al.* 2007 and Anderyev *et al.* 2002). However, the expected production rates were far too low (e.g. 1 ion/s for ^{182}Pb) for the laser spectroscopy techniques used previously at ISOLDE. Instead, an extremely sensitive spectroscopic technique was employed: resonance ionization spectroscopy in the ion source, first developed at the Petersburg Nuclear Physics Institute in Gatchina for the investigation of rare-earth isotopes (Alkhazov *et al.* 1992).

The radioactive lead isotopes are produced at ISOLDE in a proton-induced spallation reaction, using protons at 1.4 GeV on a thick (50 g/cm^2) target of uranium carbide (UC_x). The reaction products diffuse out of the target toward the ionizer tube, which is heated to around 2050 °C. In the tube, a three-step laser ionization process selectively ionizes the lead isotopes. To determine the isotope shift of the appropriate optical spectral line, the laser for the first excitation step is set to a narrow linewidth of 1.2 GHz and its frequency is scanned over the resonance. After ionization and extraction, the radioactive ions are accelerated to 60 keV, mass separated and subsequently implanted in a carbon foil mounted on a rotating wheel at the focal plane of ISOLDE. A circular silicon detector (150 mm^2 × 300 μm) placed behind the foil measures the α-radiation during a fixed implantation time, after which the laser frequency is changed and the implantation-measurement cycle repeated again. The implanted lead ions are counted via their characteristic α-decay.

Figure 3 shows the intensity of the α-lines as a function of laser frequency for a sequence of nuclei (with even N) from ^{188}Pb to ^{182}Pb. This reveals the optical isotope shift, which allows us to deduce the values of $\delta\langle r^2\rangle$ shown in figure 1. Similarly, the experiment also measured isotopes with an odd number of neutrons, ^{183,185,187}Pb, all of them produced in the ground and isomeric states. Note that the "isomer separation" could be obtained by tuning the laser frequency to some specific values at which only one of the isomers is selectively ionized in the cavity and subsequently extracted and analysed.

Figure 1 compares the deduced values of $\delta\langle r^2\rangle$ with the predictions of the spherical-droplet model. The deviation from these predictions increases when moving away from the Z = 82 closed proton shell of lead. The large deviation observed for the ground state of the odd-mass mercury isotopes and the odd- and even-mass platinum isotopes around N = 104 has been interpreted as a result of the onset of strong prolate deformation. In the case of lead, from ^{190}Pb downwards, the $\delta\langle r^2\rangle$ data show a distinct deviation from the spherical-droplet model. This suggests modest ground-state deformation, but comparisons of the data with model calculations show that $\delta\langle r^2\rangle$ is sensitive to correlations in the ground-state wave functions and that the lead isotopes essentially stay spherical in their ground state at – and even beyond – the N = 104 mid-shell region.

This experiment has shown that the extreme sensitivity of the combined in-source laser spectroscopy and α-detection allows us to explore the heavy-mass regions far from stability with isotopes produced at a rate of only a few ions a second (^{182}Pb). An important development would be: to use the isomer shift in the case of odd-mass-number isotopes to ionize nuclei selectively in their ground or isomeric state; to post-accelerate these with the REX-ISOLDE facility; and use the isomerically pure beams of the $13/2^+$ and $3/2^-$ isomers to investigate, for example, the influence of different spin states of the same incident particle on the reaction mechanism.

Further reading

G D Alkhazov *et al.* 1992 *Nucl. Instrum. Methods Phys. Res. B* **69** 517.
A N Andreyev *et al.* 2000 *Nature* **405** 430.
A N Andreyev *et al.* 2002 *Eur. Phys. J. A* **14** 63.
J Bonn *et al.* 1972 *Phys. Lett. B* **38** 308.
P Dabkiewicz *et al.* 1979 *Phys. Lett. B* **82** 199.
H De Witte *et al.* 2007 *Phys. Rev. Lett* **98** 112502.
R Julin *et al.* 2001 *J. Phys. G* **27** R109.
H-J Kluge and W Nörtershäuser 2003 *Spectrochim. Acta* B**58** 1031.
E W Otten 1989 in *Treatise of Heavy-ion science*, edited by D A Bromley **8** 517.
J Wood *et al.* 1992 *Phys. Rep.* **215** 101.

Résumé

Des noyaux de plomb exotiques à ISOLDE

Dans la nature, relativement peu de noyaux ont une forme sphérique dans leur état fondamental. On peut citer ^{208}Pb, qui est «doublement magique», avec des couches fermées de protons et de neutrons dans le modèle en couches. Les nouvelles mesures de rayons de charge des noyaux effectuées auprès de l'installation ISOLDE du CERN ont montré que la forme des noyaux de plomb reste essentiellement sphérique, même quand il y a trop peu de neutrons. L'expérience a eu recours à la spectroscopie optique pour révéler les changements apportés aux rayons dans les séquences d'isotopes de plomb, allant de ^{190}Pb à 182Pb. Ces isotopes présentent également le phénomène de «coexistence de formes» puisqu'ils peuvent avoir trois formes différentes: sphérique, allongée et aplatie.

Andrei Andreyev, *K U Leuven, and* **Jürgen Kluge**, *GSI.*

ALMA: a guided tour with Massimo Tarenghi

Massimo Tarenghi, director of the large-scale radio telescope being built in Chile's Atacama desert, took CERN's **Paola Catapano** and **Mike Struik** to see progress.

Massimo Tarenghi, director of the ALMA project, had always wanted to be an astronomer. (Photo by Paola Catapano.)

By 2010 the Chajnantor site will be covered by 64 antennas constructed in Europe, Japan and the US. The site will have 197 concrete platforms, which can be laid out in a compact configuration with a 150 m diameter, or in a large baseline configuration of 3 km diameter. The antennas will be moved around using a 150 t transporter.

Massimo Tarenghi has been described as "an excellent scientist and an energetic manager" by physics Nobel laureate Riccardo Giacconi, his colleague and fellow pupil of Beppo Occhialini. Tarenghi had wanted to be an astronomer since childhood. He graduated from the University of Milan with a degree in theoretical astrophysics, plus a thesis on gamma radiation from the galaxy core. In Arizona he took part in the first research work on large-scale galaxy distribution. He returned to Europe to lay the foundations of the European Organization for Astronomy in the Southern Hemisphere (ESO) at CERN, where ESO had its first offices.

Like Giacconi, Tarenghi is a pioneer of the first large telescopes. He put forward the idea of building ESO's Very Large Telescope (VLT) and directed the project from 1986 to 2002, commuting from ESO's eventual premises in Garching, Germany, to the telescope's site in the Paranal desert in Chile. He was appointed director of the Atacama Large Millimetric and Submillimetric Array (ALMA) in 2003, which is under construction in northern Chile on the Chajnantor plateau of the Atacama desert, the highest desert in the world. ALMA is a radio telescope made up of 64 antennas over an area of 25 km^2 at an altitude of 5100 m.

As we climb by jeep from the Operation Support Facility (OSF), ALMA's base camp at 2900 m, to the construction site at 5100 m, Tarenghi tells us: "When ALMA is ready in 2010, it will be to astronomers the equivalent of the LHC to particle physicists." ALMA will be operated from the OSF, which will also house offices and laboratories. The ALMA assembly hall and the control room to operate the telescopes remotely are under construction. The circular structure of the buildings echoes the Atacameno architecture, honouring the 20 000 indigenous population who have lived in this extreme environment for 10 000 years. They will be given free access and job opportunities on the ALMA site.

By late August, three of the antennas had been shipped to Chile from Japan. Assembly and adjustment is taking place in the assembly hall, with the first of the three expected to be installed on the Chajnantor site before the end of the year. "Most of the work after commissioning will also be done here, just below 3000 m, which is surely more comfortable than above 5000 m, where there is 50% less oxygen in the air. It is also more convenient from a legal point of view," says Tarenghi.

Before leaving the OSF, we went through medical screening to check blood pressure and oxygen levels and we collected oxygen bottles for the trip. With the magnificent background of ▷

CERN's logo 5100 m above sea level on the ALMA site at Chajnantor, with Paola Catapano (left) and Mike Struik.

The remarkably flat access road to the remote Chajnantor site (top) passes rare species of centennial cacti.

the snow-capped Licancabur and Lascar volcanoes, the road to Chajnantor winds up through the Atacamenos archaeological sites and past examples of *Echinopsis atacamensis*, a rare protected species of centennial cacti that grows up to 9 m tall and only at altitudes of 3200–3800 m. The exceptionally flat access road is 20 km long and 12 m wide. It was built specially to enable the smooth transportation of the 64 antennas from the base camp to the Chajnantor site. The builders had to go around the cacti and archaeological remains to leave them untouched.

After stopping a few times to adjust to the altitude, we reach the ALMA site at 5100 m, and admire the view, which was literally breathtaking. The site has been chosen because of its ideal conditions for radio astronomy. Being isolated guarantees the total absence of other radio signals from human communications. The lack of humidity, which would otherwise absorb the millimetre and submillimetre emissions that ALMA is designed to catch, is also important. Tarenghi explains: "Most of the energy of the universe is made of the millimetric and submillimetric radio waves that ALMA is specialized in. In this area of the electromagnetic spectrum, half of the stars in the universe are formed inside intergalactic dust, which makes them invisible to optical telescopes. Here interesting astronomical phenomena take place, such as the birth of new stars and galaxies, immediately after the Big Bang. ALMA will be able to tell 90% of the history of the universe, which we still do not know. Moreover, in the submillimetric radio waves organic molecules are found, such as carbon and sugars. They are the origin of life in space, far from the Earth."

On the Chajnantor we reach the Atacama Pathfinder Experiment (APEX), the first antenna installed on the ALMA site in 2004. It has a disc of 12 m diameter and weighs 120 tonnes. "APEX already obtained an important result in August 2006. It found fluorine, the first organic molecule to be found in the intergalactic dust of the Orion Nebula – a nice start that shows the scientific richness of this area of the spectrum. We have all the more reason to expect spectacular discoveries after 2010," Tarenghi tells us.

In 2010 the site will be covered by 64 antennas similar to APEX, made in Europe, Japan and the US. Their signals will be combined by interferometry, making a combined radio telescope as big as the distance between two antennas. The site will have 197 concrete platforms to enable astronomers to lay out the 64 antennas according to their needs. The "compact" configuration, with a 150 m diameter around the centre of array (COFA), will be used to observe a slice of the sky at the maximum resolution (20 μm). The large array with a 3 km diameter will enlarge the visual range exactly like the zoom of a camera. (An array of diameter more than 10 km is also under construction) Tarenghi adds: "ALMA will be like Hubble on Earth. It's a unique effort by Europe, the US and Japan. Like VLT, ALMA is different from other observatories not just for the size and number of telescopes in the array, but because it was designed from scratch as an astronomical research machine with all the telescopes being part of a large unit – like the accelerator complex at CERN, in a way."

As former director of the VLT, Tarenghi can uniquely explain how the two projects differ. "VLT looks at the hot universe, ALMA is specialized in the cold universe. The difference is enormous. ALMA will explore areas that are not accessible to optical telescopes. In the millimetric radio waves, luminosity decreases and in the cold areas you have clouds, dust, disks where entire planetary systems are formed around stars. ALMA will be able to see the first galaxies in the universe as they were born around 14 billion [thousand million] years ago," says Tarenghi.

He also explains to us why ALMA will be able to see the origin of life in space. The submillimetre region that ALMA specializes in is also the area where organic molecules are born and where planets form around other stars. ALMA will detect the emission of the atmospheres of other planets and will be able to find the ▷

presence of life. "Through the physical and chemical analysis of the atmosphere, ALMA will detect the presence of water, find out when dust grains formed and reconstruct the molecular history of the universe," he says. "It will map the presence of water to the extreme limits of the universe and stand the highest chance, compared with any other instrument, to find life on other planets."

The real innovation that ALMA will bring about is a radical change in the way astronomers work. "ALMA will be an all-rounder, an observatory open to all astronomers, irrespective of their specialization," says Tarenghi. "Instead of sharing observation time, astronomers will have access to ALMA's data. Like LEP or the LHC, ALMA will provide access to scientific data that can be used by the entire community, including theoreticians who want to test a theory. This is a huge new step in astronomy."

The goals of ALMA reflect the challenges in astronomy today. Tarenghi tells us: "We are ignorant of the way planetary systems are formed, we do not know how the first objects were formed and what they looked like, what is the birth rate of stars in the universe. We know the first galaxies were made of just hydrogen and the second generation of heavier elements, but the process that gave origin to the formation of planets was born from a sequence of birth and death of stars that we do not know with accuracy. Only by going to large distances with telescopes that can perform both a physical and chemical analysis, we will be able to understand the mechanism that formed stars and reconstruct the history of the stars' birth rate." Investigating dark matter and energy are also challenges for ALMA, and are shared with experiments at the LHC. "These phenomena require a detailed knowledge of the large-scale structures of the universe. Only instruments like ALMA and telescopes like VLT, which can reach the limits of the warm universe, will give us an idea, as they can provide more data from different observation sources," concludes Tarenghi. It seems that ALMA, like the LHC, is set to give us a much clearer view of the nature of the universe.

Résumé

ALMA: Visite guidée en compagnie de Massimo Tarenghi

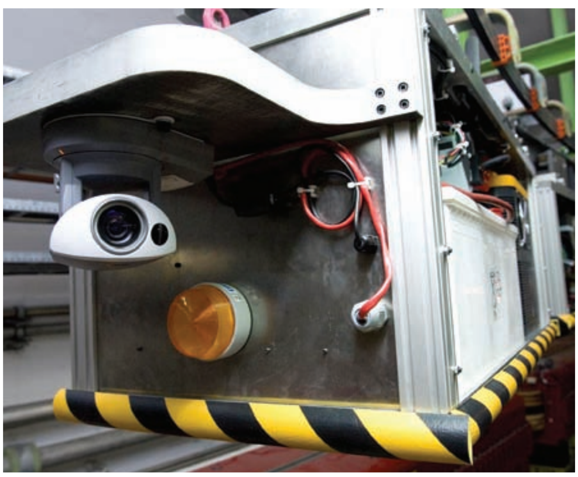
Le Grand réseau millimétrique et submillimétrique de l'Atacama (ALMA) est un nouveau radiotélescope de grande envergue en construction sur le plateau de Chajnantor, dans le désert d'Atacama, le plus haut du monde. Il comprendra 64 antennes, éparpillées sur 25 km² à 5100 m d'altitude. Ce site a été choisi pour son isolement et son absence d'humidité. En début d'année, le directeur, Massimo Tarenghi, a invité Paola Catapano et Mike Struik du CERN à venir constater l'avancement des travaux. Durant cette visite, il a décrit les objectifs du nouveau télescope, qui observera notamment les premières galaxies, nées il y a environ 14 milliards d'années, et les atmosphères entourant les planètes en orbite autour d'autres étoiles.

Paola Catapano, *CERN, with photos by* **Mike Struik**, *CERN.*

Postcards from the LHC

The photographers at CERN provide an impressive record of work on the LHC project. This selection gives a glimpse of the progress made so far this year.

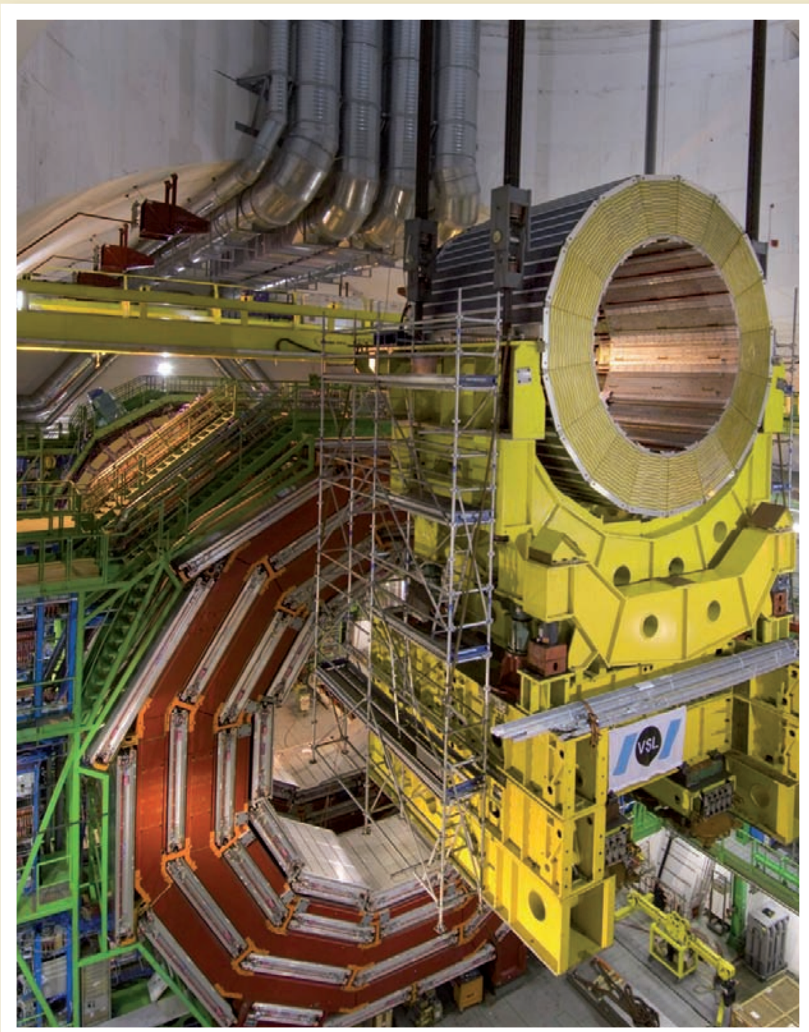
March: Precision is the name of the game as, once in position in the tunnel, the LHC's magnets are carefully aligned.



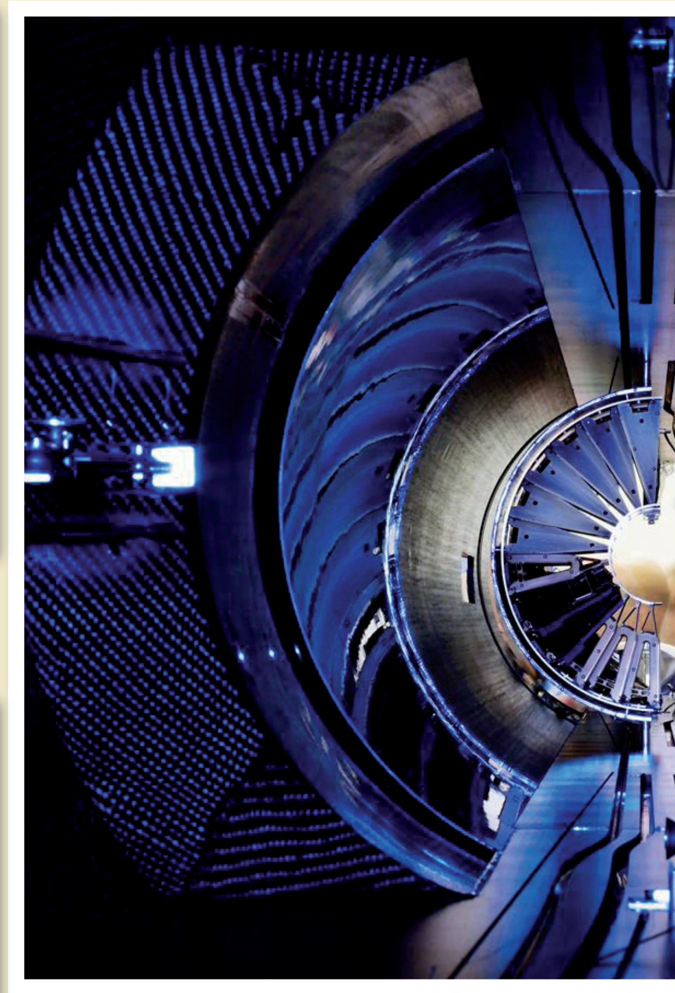
March: The Train Inspection Monorail, affectionately referred to as "TIM," will allow teams to view the LHC tunnel and take measurements remotely when it is inaccessible to humans.

The last of 1746 superconducting magnets is lowered into the LHC tunnel via a specially constructed pit at 12.00 on 26 April. This 15 m long dipole magnet is one of 1232 dipoles that will guide the two proton beams in opposite directions around the 27 km circumference.

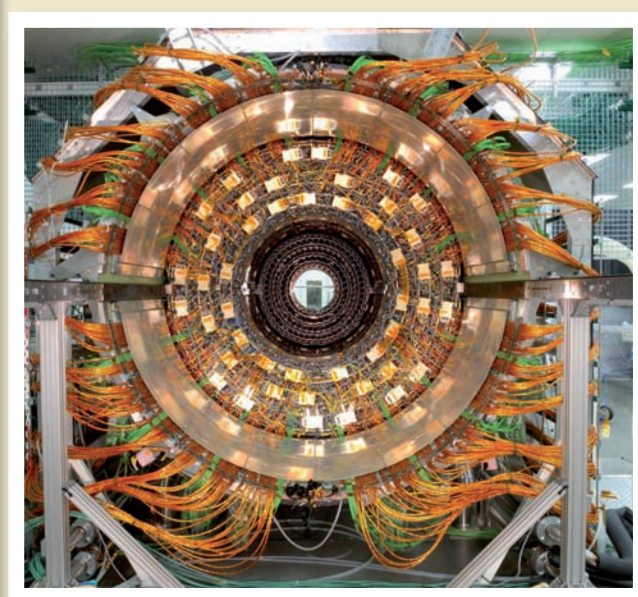
Gently does it: In January, the lorry transporting the time projection chamber for the ALICE experiment took an hour to travel the 200 m from the assembly hall to the access shaft for the underground cavern.



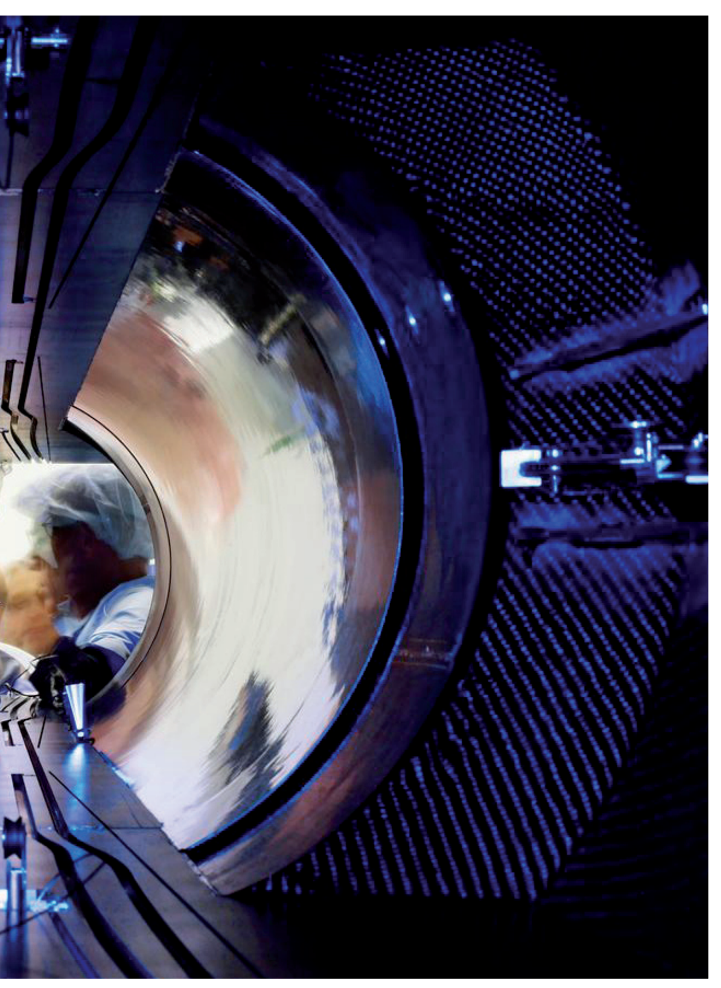
The first half of the CMS barrel hadron calorimeter cylinder was lowered into the underground cavern in February. It weighs almost 600 tonnes.



In July the CMS forward pixel detector, which was built at Fer
central opening of the silicon strip tracker where the beam p

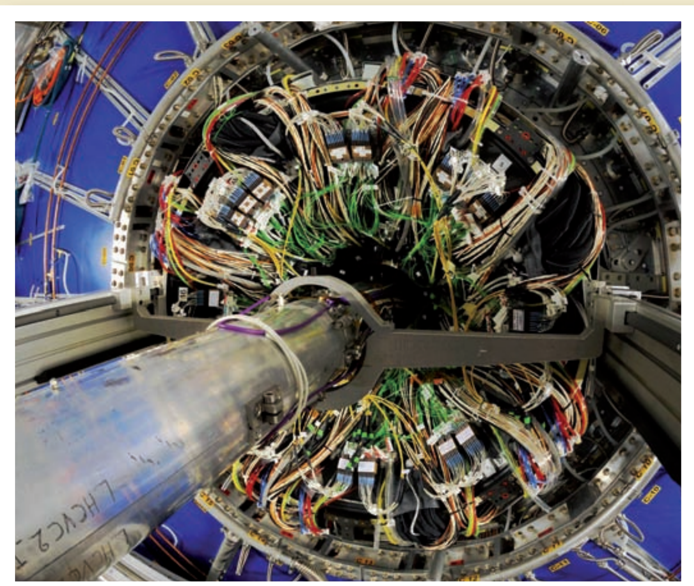


January: The CMS tracker outer barrel is inside the tracker support tube, fully cabled. The golden rectangles are digital optohybrid modules for distributing clock and trigger signals.

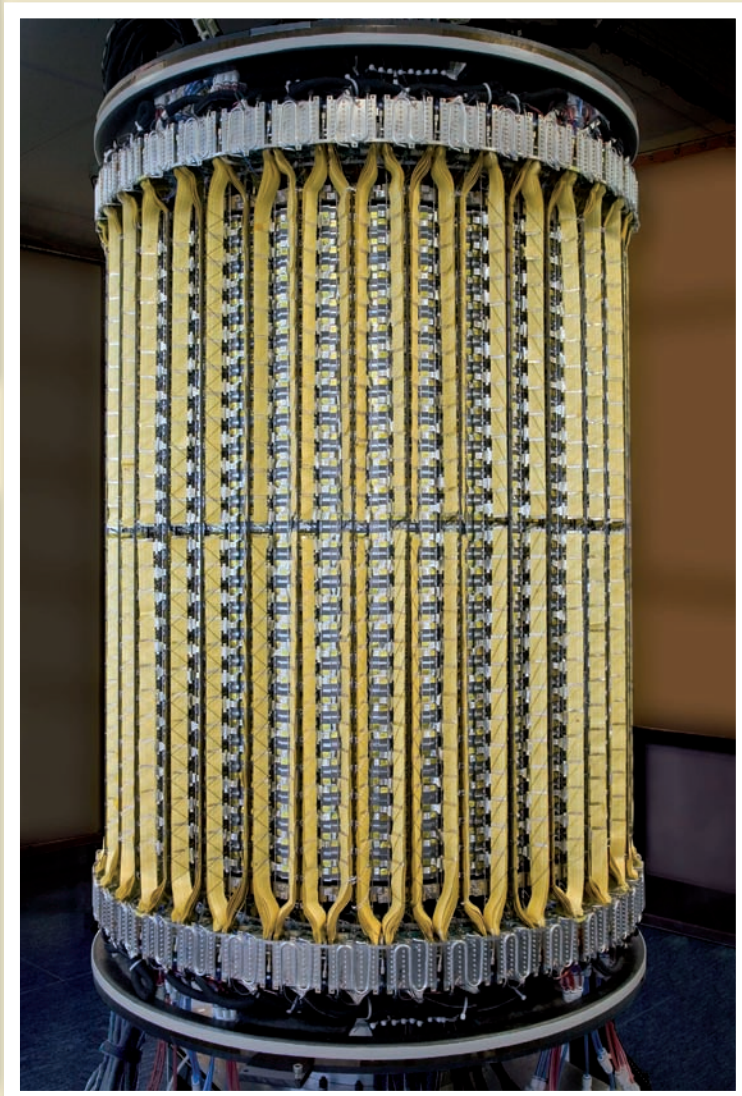


ermilab, underwent an installation test. The photo shows the pipe and pixel detector will be located.

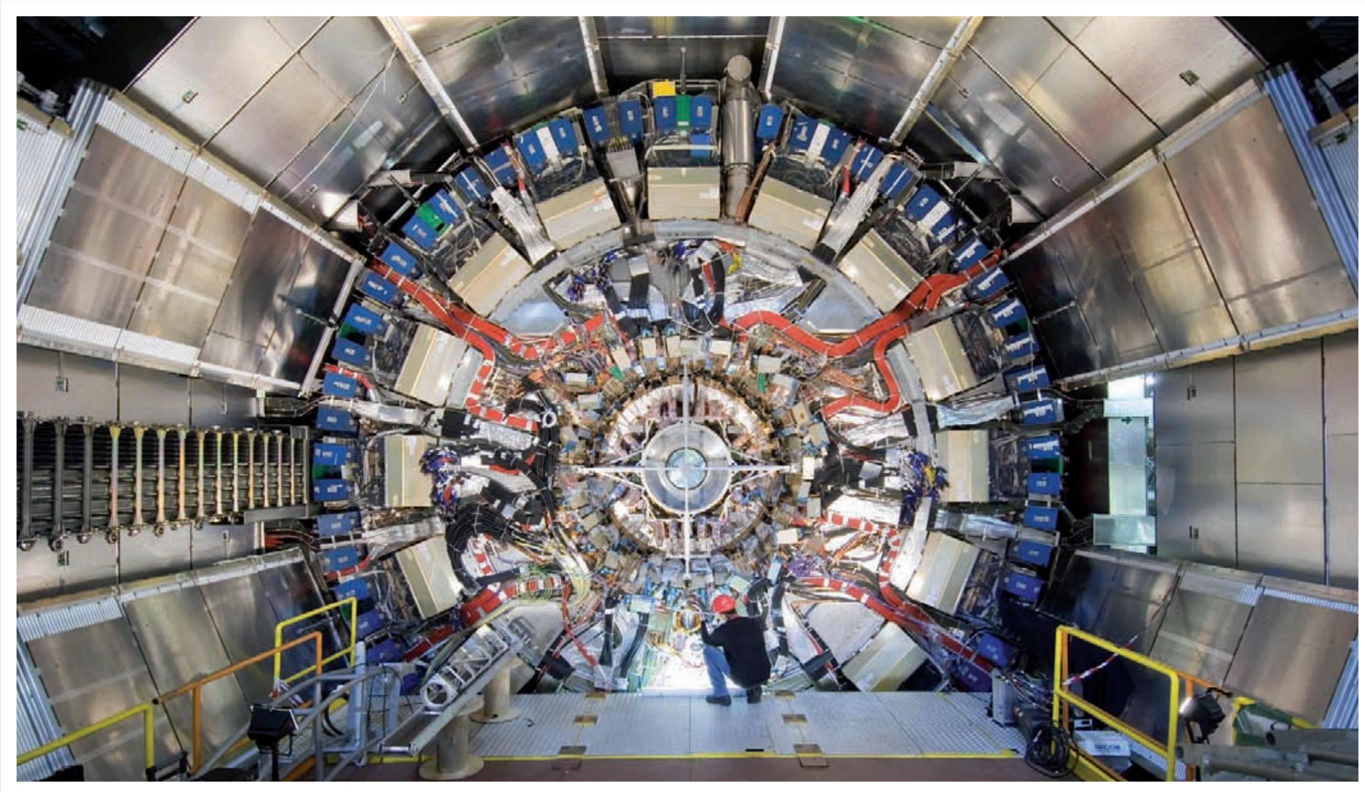
The 42nd and final module for LHCb's vertex locator arrived from Liverpool in March, marking the culmination of 10 years of development. The detector will be placed just 5 mm from the beam line.



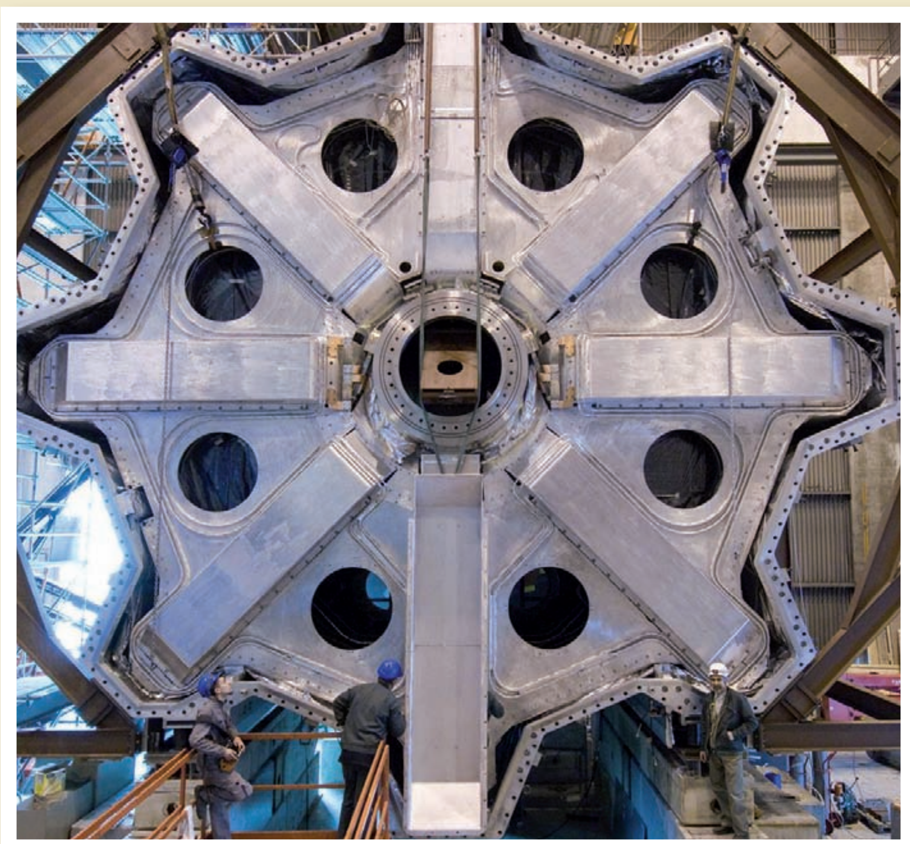
ALICE's inner tracking system (ITS) was installed into the heart of the experiment in March. It was a delicate task to fit the ITS within the time projection chamber.



The outer layers of ALICE's ITS, seen prior to installation in March, contain almost 5 m^2 of double-sided silicon strip detectors.



The first inner detector endcap for the ATLAS experiment is fully inserted into the liquid-argon cryostat in May.



March: End view of the heat shield and cryostat of one of the ATLAS endcap toroids while still in the assembly hall before the mounting of detectors.

Lowering the second ATLAS endcap toroid magnet into the cavern in July.

Father of the shell model

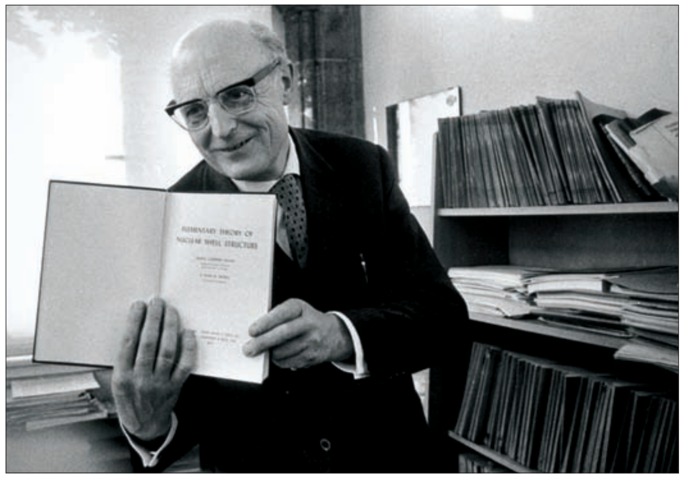
Heidelberg University held a symposium on fundamental physics and the shell model this summer to celebrate the 100th anniversary of the birth of Hans Jensen, the German who created the nuclear shell model with Maria Goeppert-Mayer of Argonne.

Hans Jensen (1907–1973) is the only theorist among the three winners from Heidelberg University of the Nobel Prize for Physics. He shared the award with Maria Goeppert-Mayer in 1963 for the development of the nuclear shell model, which they published independently in 1949. The model offered the first coherent explanation for the variety of properties and structures of atomic nuclei. In particular, the "magic numbers" of protons and neutrons, which had been determined experimentally from the stability properties and observed abundances of chemical elements, found a natural explanation in terms of the spin-orbit coupling of the nucleons. These numbers play a decisive role in the synthesis of the elements in stars, as well as in the artificial synthesis of the heaviest elements at the borderline of the periodic table of elements.

Hans Jensen was born in Hamburg on 25 June 1907. He studied physics, mathematics, chemistry and philosophy in Hamburg and Freiburg, obtaining his PhD in 1932. After a short period in the German army's weather service, he became professor of theoretical physics in Hannover in 1940. Jensen then accepted a new chair for theoretical physics in Heidelberg in 1949 on the initiative of Walther Bothe, who received the Nobel prize in 1954 for the development of the coincidence method. Apart from his work in nuclear and particle physics, Jensen became the driving force behind the rebuilding of physics research in Heidelberg after the Second World War. The Institute for Theoretical Physics obtained new chairs, particularly in theoretical particle physics. Together with Bothe, he expanded the experimental-physics department and convinced well-known experimentalists to come to Heidelberg, including his collaborator in the development of the shell model, Otto Haxel, in 1950 and Hans Kopfermann, a specialist on nuclear moments and hyperfine interactions, three years later.

The shell model past and present

To celebrate the centenary of Jensen's birth, the Heidelberg Physics Faculty and the Institute for Theoretical Physics organized a symposium on Fundamental Physics and the Shell Model. A series of talks looked at Jensen's life plus the role of the shell model in astrophysics and nuclear physics today. In keeping with Jensen's interest in music, performances by the Heidelberg Canonical Ensemble complemented the talks. In the introductory talk on The Shell Model: Past and Present, former director at the Heidelberg Max Planck Institute, Hans Weidenmüller, gave an overall view of Jensen's Nobel-prizewinning contribution to nuclear physics. The paper on the shell model by Haxel, Jensen and Hans Suess appeared in the same 1949 edition of *Physical Review* as Goeppert-Mayer's work (Haxel, Jensen and Suess 1949 and Goeppert-Mayer 1949). It proved to be a surprising solution to the problem of nuclear-energy levels. Based on the picture of independent particle motion of protons and neutrons with strong spin-orbit coupling, the model yields the correct sequence of energy levels and explains the magic numbers in terms of energy gaps above full levels.



Hans Jensen in his study at 16 Philosophenweg, Heidelberg in 1963. (Courtesy Bettmann/UPI/Corbis.)

The apparent contradictions with the collective properties of nucleons in nuclei (evident from the rotational spectra) as well as with the chaotic properties of nuclei (evident in Niels Bohr's compound nucleus picture) only found their explanations much later. Today, shell-model calculations in large configuration spaces can indeed explain rotational spectra, and within individual shells consistency with the random nuclear properties appears once the residual interaction is considered. However, a derivation of the shell model from the basic nucleon–nucleon interaction is still missing.

Berthold Stech, Jensen's former colleague and long-time director of the Heidelberg theory institute, presented his recollections of Jensen with photographs and anecdotes. As a student representative after the war, Stech contributed to Jensen's move to Heidelberg by writing a letter to the publisher of the local newspaper, who then went to the state government to ensure that the offer was made to Jensen. He talked about Jensen's vital contributions to making Heidelberg a famous physics centre. With private rooms in the institute, Jensen often invited students and colleagues for discussions and to listen to music. Stech also quoted from a recent letter by Aage Bohr and Ben Mottelson, who emphasized Jensen's inspiring personality. ▷

The theory institute at Philosophenweg

A bronze plaque at the "Jensen Haus" in Heidelberg. (Courtesy G Wolschin.)

As part of his effort to convince Hans Kopfermann to move to Heidelberg University, Jensen supported the acquisition of a house at 16 Philosophenweg by the German state of Baden-Württemberg. The villa had been built in 1912 for the biologist Hugo Merton, who was deprived of his professorship at Heidelberg in 1935 by the Nazi racial decrees and was deported to the Dachau concentration camp in November 1938. Merton was able to emigrate – but not before being forced to sell his house – to Scotland, where he died in 1940. After the war, the house was given back to the Merton family. As they did not want to return to Germany, they sold the house to the university. Jensen and the Kopfermann family lived there from 1953, and at the same time, Jensen built up Heidelberg's Institute for Theoretical Physics. As part of the celebrations for the centenary of his birth, the villa was renamed "Jensen Haus", and a bronze plaque with his portrait was unveiled, created by the Darmstadt artist Thomas Duttenhoefer.

Wolfgang Hillebrandt, director at the Max Planck Institute for Astrophysics in Munich-Garching, spoke about supernovae and the shell model. This active field of research represents a synthesis of astrophysics and nuclear physics. In Type Ia supernovae there is a high and almost identical fraction of nickel-56. Even though this is a doubly magic nucleus, it is not stable (its half-life is six days) and its decay through cobalt-56 to iron-56 is what makes these supernovae shine. Hence, the brightness of the supernova is proportional to the produced mass of nickel-56. For progenitor stars that are similar, this allows for very precise determination of distances, which since 1998 have been used to infer the accelerated expansion of the universe. Many physicists consider this to be the consequence of dark energy. Its origins are currently under investigation in many institutes, for example, at the Bonn–Heidelberg–Munich research centre "The Dark Universe".

Core-collapse supernovae (Type II), such as SN1987A in the Large Magellanic Cloud, where a blue supergiant exploded in several seconds, allow the direct test of ideas about the synthesis of heavy elements. For example, observations of the characteristic gamma rays indicate the presence of the corresponding isotopes synthesized in the particular star or during the explosion. Elements beyond iron are, in particular, produced in a sequence of rapid neutron captures known as the r-process. It turns out that the element abundances are mainly determined by nuclear structure, and hence, by the shell model; the subtleties of the astrophysical processes prove to be comparatively unimportant.

In the final talk of the symposium, Peter Armbruster of the GSI in Darmstadt explained the synthesis of the heaviest elements using cold fusion (only one neutron emitted) up to and beyond roentgenium, symbol Rg and atomic number $Z = 111$. The relative stability of these elements, with mean lifetimes in the order of milliseconds to seconds, is a consequence of the Goeppert–Jensen shell effects. Without these they would not exist. The element $Z = 112$, synthesized at GSI in 1996, is still unnamed. Meanwhile, Yuri Oganessian's group at the Flerov Laboratory at JINR, Dubna, used radioactive targets in hot-fusion reactions with the emission of up to five neutrons, to create synthetically the elements 114, 116 and 118. Kosuke Morita and co-workers at RIKEN in Japan made element 113 in 2004.

Relativistic mean-field calculations indicate that the closed shell should occur at $Z = 120$ (the number of protons), with the magic neutron number of 184, as had appeared in the book of Jensen and Goeppert-Mayer about the shell model (Goeppert-Mayer and Jensen 1955). This means that this doubly magic superheavy nucleus should have 304 nucleons. It will, however, be extremely difficult to synthesize since its relatively low density of energy levels above the ground-state favours fission over neutron emission, as Armbruster emphasized. This would lead to a drastic reduction of the survival probability.

As a lasting tribute to Jensen, starting next year, the Jensen Guest Professorship will be created with the financial support of the Klaus Tschira Foundation, Heidelberg. During a five-year period, internationally renowned physicists will visit the Institute for Theoretical Physics in Heidelberg to conduct research, give seminars and one public lecture a year.

Further reading

H G Dosch and B Stech 1986 *"Johannes Daniel Jensen" Semper Apertus, 600 Jahre* Ruprecht-Karls-Universität Heidelberg Band **3** 417.

M Goeppert-Mayer and J H D Jensen 1955 *Elementary theory of nuclear shell structure* (Wiley, New York).

M Goeppert-Mayer 1949 *Phys. Rev.* **75** 1969.

O Haxel, J H D Jensen and H E Suess 1949 *Phys. Rev.* **75** 1766.

Résumé

Colloque en l'honneur de Hans Jensen

Cet été, à l'occasion du centième anniversaire de la naissance de Hans Jensen, à qui l'on doit, avec Maria Goeppert-Mayer, d'Argonne, le modèle en couches, l'Université de Heidelberg organisait un colloque sur le thème: physique fondamentale et modèle en couches. Les deux physiciens ont partagé en 1963 un prix Nobel pour ces travaux, publiés indépendamment en 1949. Le modèle constitue la première explication cohérente des diverses propriétés et structures des noyaux atomiques, en particulier, les « nombres magiques » de protons et de neutrons. Ceux-ci jouent un rôle important dans la synthèse des éléments dans les étoiles et dans la synthèse artificielle des éléments les plus lourds – sujets qui sont à la pointe de la recherche moderne en physique nucléaire.

Georg Wolschin, *Heidelberg University.*

The LHC: a new high energy photon collider

The LHC will deliver proton–proton and nucleus–nucleus collisions at unprecedented energies, and it will be the first photon collider ever built at tera-electron-volt energies.

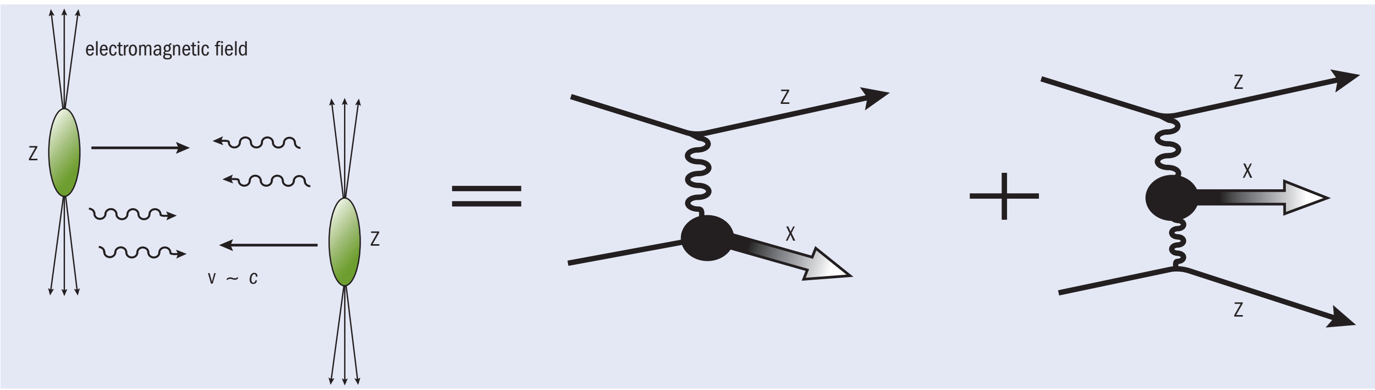


Fig. 1. The electromagnetic collision of protons or heavy ions (with charge Z) at the LHC will allow the study of photon-induced processes at the highest energies ever reached in the laboratory, in the region of tera-electron-volts.

Photon-induced interactions have traditionally been studied with electron beams in fixed-target experiments and colliders, LEP (electron–positron) and HERA (electron–proton) in particular. However, photon–hadron and photon–photon interactions also occur when the electron beams are replaced by ultra-relativistic beams of other charged particles such as protons or heavy nuclei. In these cases, the maximum photon energies are restricted by the form factor of the projectile, but at the extremely high energies of the LHC they will be higher than at any other existing accelerator: up to a photon energy of around 4 TeV in the photon–proton centre-of-mass frame. Furthermore, since the intensity of the electromagnetic field – the number of photons in the "cloud" surrounding the charge of the beam particle – is proportional to the square of the particle's charge Z, photonic interactions are enhanced by up to a factor of Z^2, or around 10^4 for heavy ions. Indeed, the fields from heavy ions are strong enough that multiple photons may be exchanged in a single event. Figure 1 shows a schematic view of such an electromagnetic (or ultra-peripheral) nucleus–nucleus collision.

The study of photon-induced interactions at the LHC, as well as at existing hadron colliders such as RHIC at Brookhaven or the Tevatron at Fermilab, is challenging despite the high photon energies and fluxes. The interaction is always electromagnetic with an electron beam and the small contribution from the weak interaction can usually be neglected or easily separated. By contrast, the photonic interactions at hadron colliders must be separated from a dominant QCD background. The low multiplicity and mostly longitudinal kinematics of electromagnetic processes result in an event topology that is different from hadronic interactions. In particular, event triggering is a critical issue that depends much on instrumentation in the very forward direction, close to the beam line. The workshop on Photoproduction at collider energies: from RHIC and HERA to the LHC (held at ECT*-Trento in January), looked at how these issues have been addressed and solved in previous experiments, and considered the perspectives at the LHC. The workshop gathered around 40 physicists, equally divided between theorists and experimentalists.

Much of the workshop focused on the latest advances in the study of low-x parton densities in protons and nuclei probed by photons. Ultra-peripheral collisions at the LHC can probe the physics of parton saturation at Bjorken-x values as low as 10^{-5}. Talks by SLAC's Stan Brodsky, Mark Strikman of Pennsylvania and Leonid Frankfurt of Tel Aviv highlighted these theoretical aspects. HERA saw its last collisions at the end of June and has been an important machine for the field. Michael Klasen from Grenoble and DESY's Sergey Levonian gave theoretical and experimental overviews, respectively, of the HERA results. At the Tevatron, the CDF collaboration has recently published its first analysis of two-photon interactions in proton–antiproton collisions. Andrew Hamilton of Geneva presented the results at the workshop. At RHIC, ▷

the STAR and PHENIX collaborations have studied ultra-peripheral gold–gold collisions. Yury Gorbunov of Creighton and David Silvermyr from Oak Ridge showed the latest results on vector meson photoproduction.

Looking to the future, Krzysztof Piotrzkowski from UC Louvain presented the group's comprehensive study of various photon-induced electroweak and beyond-Standard Model processes that can be studied in proton–proton collisions at the LHC. These include associated W-Higgs and single-top photoproduction, as well as two-photon production of W boson pairs. To conclude the series of talks at the workshop, Otto Nachtmann of Heidelberg and Ute Dreyer of Basel covered the theory of anomalous gauge-boson couplings in γ–γ, γ–p and γ–A interactions.

The physics of photon–nucleus interactions in ultra-peripheral collisions is also the focus of a CERN Yellow Report, completed in June. This 230-page document, the joint effort of more than 20 contributors, summarizes results from the SPS at CERN and from RHIC. It examines planning for ultra-peripheral collisions at the ALICE, ATLAS, and CMS experiments at the LHC. The vitality of this research field was also evident in the number of contributions at the Photon 2007 conference held in Paris in July.

The conclusion is that the LHC has much to offer as a photon collider. Photon–hadron and photon–photon processes will reach energies an order of magnitude larger than at previous colliders. They will not only provide valuable information on the strong interaction – in particular of low-x parton densities and non-linear QCD phenomena – but will also open new windows on electroweak processes and physics beyond the Standard Model, which will complement the mainstream studies in proton–proton and nucleus–nucleus collisions.

Further reading

Summaries of the ECT*-Trento workshop talks are available at http://arxiv.org/abs/hep-ph/0702212.
The CERN Yellow Report on ultra-peripheral collisions can be accessed at http://arxiv.org/abs/0706.3356.

Résumé

Le LHC: un nouveau collisionneur de photons de haute énergie

Traditionnellement, on étudie les interactions induites par les photons dans des faisceaux d'électrons dans le cadre d'expériences avec cibles fixes, ainsi que dans des collisionneurs, en particulier le LEP et HERA. Mais on peut aussi observer les interactions de photons dans des faisceaux de protons ou de noyaux lourds ultra-relativistes. Au LHC, les énergies de photons maximum seront plus élevées que dans aucun autre accélérateur existant – jusqu'à 4 TeV dans le centre de masse du système photon–proton. Elles permettront d'obtenir, non seulement des informations précieuses sur les interactions fortes, mais aussi de nouvelles perspectives sur les processus électrofaibles et la physique au-delà du modèle standard, qui seront complémentaires des études classiques sur les collisions proton–proton et noyau–noyau.

David d'Enterria, *CERN, and* **Joakim Nystrand**, *University of Bergen.*

FACES AND PLACES

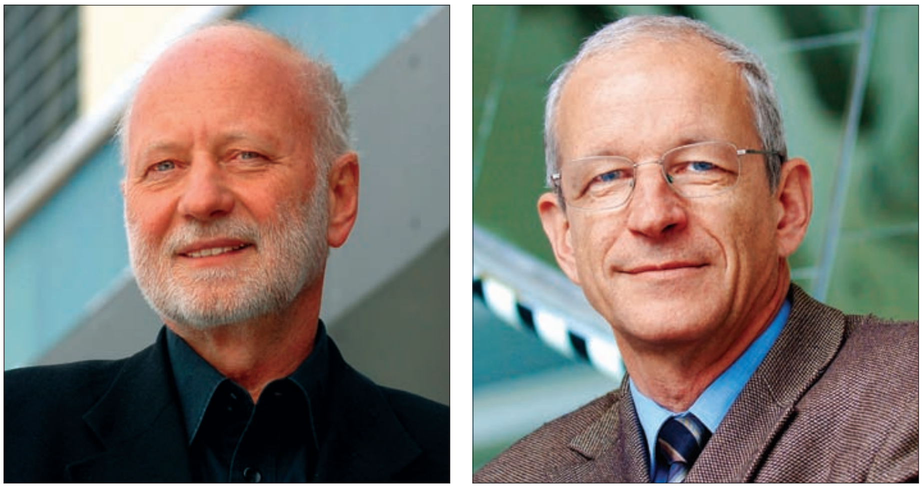
APPOINTMENTS

All change for directorate at PSI

Ralph Eichler has stepped down as director of the Paul Scherrer Institut (PSI) to become president of the Swiss Federal Institute of Technology (ETH) Zurich. The Swiss Federal Council elected him in May, and he took up the post at the beginning of September, after more than five years as director of PSI.

During Eichler's time at the helm, PSI has continued its growth with a diversity of new projects and facilities. In the field of accelerators, for example, these range from the expansion of the Swiss Light Source (a synchrotron radiation facility) via a new proton-therapy facility, PROSCAN, to the initiation of the project for a future compact X-ray free-electron laser facility, PSI-XFEL.

Martin Jermann, current vice-director of planning and operations and long-standing chief-of-staff of the PSI directorate, will succeed Eichler as interim director of PSI. Jermann has a great interest in proton therapy, and as head of the proton-therapy programme he has played a leading role in planning and commissioning the PROSCAN project (*CERN Courier* December 2006 p24). The Swiss Federal Council has also appointed two new vice-directors. Friso van der Veen and Alexander Wokaun take on special responsibilities for the PSI-XFEL project and for energy research, respectively.



Martin Jermann (left) takes over from Ralph Eichler at the helm of PSI. (Courtesy PSI.)

AWARDS

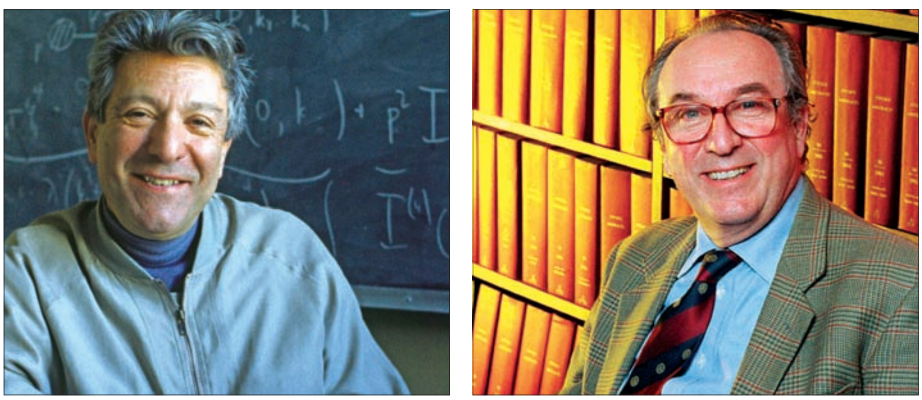
Iliopoulos and Maiani receive Dirac medal

The Abdus Salam International Centre for Theoretical Physics (ICTP) has awarded the 2007 Dirac medal to Jean Iliopoulos, emeritus director of research at the Laboratory of Theoretical Physics of the Centre National de la Recherche Scientifique, and Luciano Maiani, former director-general of CERN and now at Rome's La Sapienza University. The medal honoured the two physicists for their joint "work on the physics of the charm quark, a major contribution to the birth of the Standard Model, the modern theory of elementary particles".

In 1970, Maiani and Iliopoulos – together with Sheldon Glashow of Harvard – made an invaluable contribution to electroweak theory when they postulated what became known as the Glashow–Iliopoulos–Maiani (GIM) mechanism. One implication of this was the existence of new, fourth quark, the charm quark (discovered in 1974), with properties similar to those described in the original paper on the GIM mechanism. Their work has also contributed to the development of the Standard Model.

The announcement of the annual award, which the ICTP established in 1985, is always on 8 August, the birthday of Paul Dirac. It recognizes fundamental contributions to theoretical physics or mathematics.

Recipients of the Nobel prize, the Fields medal or the Wolf foundation prize are not eligible – so ruling out Glashow, who received the Nobel prize in 1979 for his work on electroweak theory, together with Abdus Salam and Steven Weinberg.



Left: Jean Iliopoulos. (Courtesy CNRS Photothèque/Julien Quideau.) Right: Luciano Maiani.

WFS honours André Martin with 2007 Gian Carlo Wick medal

Theoretical physicist André Martin received the 2007 Gian Carlo Wick Gold Medal in a ceremony in Erice on 20 August. Martin won the award for "his proof of an entire set of rigorous analyticity and symmetry properties of scattering amplitude in particle physics, including the Froissart–Martin bound on total cross-sections, and for his comprehensive analysis of the heavy quark systems in sub-nuclear physics".

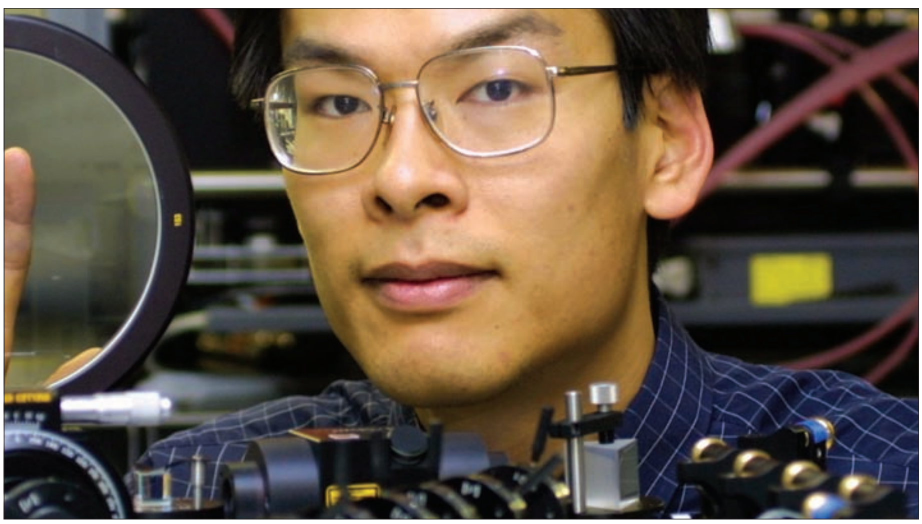
The World Federation of Scientists (WFS) awards the medal each year to a theoretical physicist for outstanding contributions to particle physics. Nobel prize laureate TD Lee chairs the selection committee, which is composed of eminent physicists.

André Martin (centre) together with TD Lee (left), chair of the selection committee, and Antonino Zichichi (right), president of the World Federation of Scientists. (Courtesy WFS.)

In 1965, Martin established a theoretical basis for the Froissart bound, which limits the total cross-section for the interaction between two particles. He went on to do extensive work on quarkonium systems, establishing new properties for the Schrödinger equation on these systems. The quarkonia model was later extended to baryons. Martin was in the theory division at CERN from 1959 until he retired in 1994, and he still works at CERN on theoretical physics.

Masaki Hori wins EURYI award

High-precision spectroscopic measurements on atoms made wholly or partly from antiparticles at CERN's Antiproton Decelerator have received a boost with a prestigious award to Masaki Hori of the ASACUSA collaboration. Hori has received a European young investigator (EURYI) award and research grant to develop his work in this field. A collaboration between the European Heads of Research Councils and the European Science Foundation initiated the EURYI awards scheme in 2003. It aims to attract outstanding young researchers worldwide to create their own research teams at European research centres.



Hori, winner of a prestigious award for young researchers. (Courtesy ASACUSA.)

Hori, who is Japanese, will be affiliated with the Max Planck Institute for Quantum Optics in Garching, and undertake the research at CERN's Antiproton Decelerator. He is currently at the University of Tokyo but spends most of his time at CERN. His was one of 20 successful projects selected from more than 450 applications. He aims to break new ground in handling and storing antiprotons to create antihydrogen atoms.

Hori and colleagues in ASACUSA laid the ground for this project in their research on the antiproton, the mass and electric charge of which the team has measured down to within a few parts per billion relative to the proton's values (*CERN Courier* May 2004 p31 and *July/August* 2006 p8).

Brightness award recognizes work by DESY engineer

Electrical engineer Jens Peters (right) receives the Brightness award from Jose Alonso, president of the award committee. The ceremony was held in Korea. (Courtesy E Gatz.)

On 27 August, Jens Peters from DESY received the Brightness award at the 2007 International Conference on Ion Sources in Korea. The award, sponsored by Bergoz Instrumentation in France, is in recognition of his contributions in the field of H-sources. Hydrogen atoms with a negative charge – H-particles – are required for effective proton production at particle accelerators.

Peters, an electrical engineer, worked on developing radio-frequency systems for the PETRA electron–positron collider at DESY and later collaborated in the construction of the HERA H-LINAC III. To develop the HERA high-frequency H-source, he used radio frequency for plasma production instead of the caesium source that is normally used, thus designing an almost maintenance-free source. DESY has since patented this source and CERN is building a copy to provide the LHC with protons. In addition, the Spallation Neutron Source at Oak Ridge uses essential parts of the source and Fermilab also plans to use them.

At the presentation of the Brightness award, there was special mention of Peters' excellent collaboration with other international institutes. A world record, for the production of the longest beam pulse with a source of this kind, has only been possible with the provision of equipment from other institutes.

Frank Close wins science-writing award for obituary

The Association of British Science Writers (ABSW) has chosen Frank Close, theoretical physicist at Oxford, as one of the 2006 winners of the Syngenta ABSW's awards. Close is well known for his books on particle physics, in particular *The Cosmic Onion*. However, it is for writing an obituary in the *Guardian* newspaper that he has received the prize for "best science writing in a non-science context".

Close's obituary on Nobel laureate and solar-neutrino pioneer, Raymond Davis, was published in the *Guardian*'s obituary section on 19 June 2006 and described Davis as "the first person to look into the heart of a star". The awards honour writers and broadcasters who have, in the opinion of an independent judging panel, produced the highest quality science journalism each year, and highlighted important issues accurately and with flair.

● Read the winning article at www.guardian.co.uk/obituaries/story/0,,1800756,00.html.

Frank Close appeared on the cover of CERN Courier *for the January/February edition in 2000. He has recently won an ABSW award for his writing about science.*

SCHOOLS

Digital signal processing debuts at CAS with resounding success

The CERN Accelerator School (CAS) and Uppsala University jointly organized a specialized school on a new theme this summer, with a course on digital signal processing, which took place in Sigtuna, Sweden, from 1–9 June.

The course was different this year in that the topic had never been treated by CAS, and unlike the usual specialized courses, the structure comprised 32 hours of theoretical lectures in the mornings and a 16-hour "hands-on" course in the afternoons. The latter (well thought out by experts from CERN) had novel logistical implications for transporting computers and evaluation boards (DSPs and FPGAs) to Sigtuna, in central Sweden.

The principle of this new approach was well received by the accelerator community. A total of 97 participants representing 23 different nationalities attended the course, with 80% of the participants originating from the CERN member states. The positive feedback from the participants showed that the course was a resounding success, all the result of the expertise and enthusiasm of the lecturers who volunteered to take on this challenge. Considering the quality of the preparatory work, as well as the experience collected during the course, it is certainly conceivable that such a course will be considered again in the not-too-distant future, either in the framework of another CAS or similar schools.

Participants at the specialized CAS school in Sigtuna. (Courtesy T Thörnlund, Uppsala.)

In addition to specialized courses, CAS also organizes general accelerator physics schools at introductory or intermediate levels. More information about this and future courses, as well as examples of lecture notes from previous CERN accelerator schools and the corresponding proceedings, can be found at www.cern.ch/schools/CAS.

ACCELERATORS

U70 reaches 40th anniversary

On 14 October the U70, or the 70 GeV proton synchrotron at the Institute for High Energy Physics (IHEP) in Protvino, in south-western Russia, marks the 40th anniversary of its successful commissioning. The machine held the record for the top beam energy during the late 1960s and became the venue for work by many research, scientific and industrial institutions from around the former Soviet Union. It continues to form the core of experimental facilities of IHEP.

The schedule for launching the U70 in 1967 was tight. In its original configuration, the machine was fed with a beam injected from the 100 MeV Alvarez-type linac (I-100), for which commissioning had started as late as July the same year. On 17 September, the first beam circulated around the main ring and, on 12 October, the accelerator team achieved the important "transition crossing" at 8 GeV. At midnight on 14 October, the U70 accelerated a beam of protons up to an energy of 76 GeV. The U70 took up an important role in high-energy physics in the late 1960s and was the focus of successful co-operation with CERN on various accelerator systems (fast extraction, controls) and experimental facilities, such as the RF separator for the Mirabelle bubble chamber and other experimental equipment (*CERN Courier* November 2003 p3). Researchers carried out more than 50 experiments at the U70 in co-operation with physicists from CERN.

During the past four decades, the accelerator complex of IHEP has been subject to an extensive upgrade programme. A new injector came into operation (the 1.5 GeV, 16 Hz fast-cycling booster proton synchrotron U1.5) in 1985 to ease the Coulomb tune-shift limitation on beam intensity. This is fed by a unique 30 MeV proton linac (URAL30) based on conventional and drift-tube RF quadrupole (RFQ) accelerator concepts that were pioneered at IHEP.

Beam physicists and engineers at IHEP continue their efforts to keep the machine running and improve the quality of the proton beam that is delivered to users. The newly built 30 MeV DTL RFQ proton linac (URAL30M) is currently being pre-commissioned, and a programme to accelerate light ions (deuterium and carbon) through the re-conditioned I-100 to the booster, and eventually to the main ring of the U70, is taking place step-by-step.

An aerial view of the U70 in Protvino, in south-western Russia. (Courtesy IHEP.)

The safety margin foreseen in the design and construction of the U70 is a legacy of the previous generations of accelerator experts, and is now a prerequisite for the continued operation of the U70 – the largest proton accelerator in Russia – for fundamental and applied research in the energy range of a few tens of giga-electron-volts.

OBITUARIES

Kjell Johnsen 1921–2007

Kjell Johnsen passed away at his home in Switzerland on 18 July following a long battle with cancer.

Kjell was born in Norway in June 1921 and studied electrical engineering at the Technical University of Trondheim. He was selected by Odd Dahl of Bergen, one of the founding fathers of CERN, to take part in the early studies for the accelerators of the future European physics centre. Kjell joined CERN in 1952 and took part in the design of the new laboratory's most ambitious project, the alternating gradient proton synchrotron, which became known as the PS. He soon developed into one of the few real accelerator experts in the world at the time.

For several years, Kjell dedicated his energy and vision to obtaining approval for the construction of the Intersecting Storage Rings (ISR), the world's first proton–proton collider. This project was approved under Kjell's leadership and construction began in 1966 – with completion in 1971. At the time, the ISR was an incredibly ambitious and controversial project. Many eminent scientists stated openly that the beams would not survive long enough to produce physics data. It is now history that the ISR is one of the great accelerator success stories. It opened up a new energy domain for high-energy physics and paved the way for the approval and construction of many larger projects, such as converting CERN's SPS into a proton–antiproton collider, the Tevatron at Fermilab and, now, the LHC. Under Kjell's leadership, the ISR project was an inspiring example of well-directed teamwork. For all of us who had the privilege to work on this machine under him, we can honestly say that this was a rewarding and uniquely major scientific experience and adventure.

Kjell Johnsen, leader of the Intersecting Storage Rings project, announced from the crowded control room that the first-ever interactions from colliding proton beams had been recorded on 27 January 1971.

Kjell was made professor at the Technical University of Trondheim, and for several years he dedicated an important part of his time to teaching at doctoral level and training young people. He was also the creator and inaugural director of the CERN Accelerator School, which has become a successful enterprise, attracting many talented and gifted young students from all over the world, and thereby promoting scientific collaboration at a European and worldwide level (see p42).

Kjell's many friends around the world have always valued his kindness, competence, intellectual honesty, seriousness, scientific vision, courage and dedication. It was to him that people always went for clarifications, advice and guidance.

We will miss him dearly. We should, however, be comforted by the thought that he has been a great example and role model to many of us. He has been respected and appreciated, and has most definitely left a permanent mark in his chosen professional field of accelerator research.

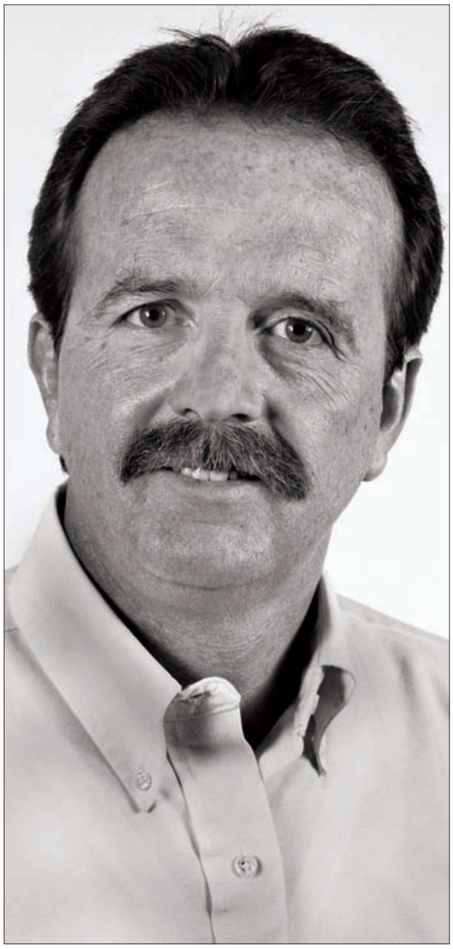
His friends and colleagues.

Mike Ronan 1949–2006

Mike Ronan, a senior staff scientist at Lawrence Berkeley National Laboratory and lecturer at the University of California, Berkeley, died tragically on 17 October 2006. A consummate experimentalist, he made substantial contributions in many areas of high-energy physics projects, from detector development and accelerators, to software design and physics analyses. He was 57 years old.

Mike received a degree in physics in 1970 from the University of Massachusetts, followed by a master's degree and, in 1976, a PhD in elementary-particle physics from Northeastern University. He came to Lawrence Berkeley Laboratory (LBL) that same year to join the Lead Glass Wall (LGW) experiment at SLAC's storage ring, SPEAR. LGW sought to confirm the existence of the tau lepton using good electron identification, as well as to study charmed meson branching ratios. The experiment discovered a new particle, the Ψ (3772), a $c\bar{c}$ state at the threshold of open charm. In addition, there was for the first time evidence for direct photon production in $e^+e^- \rightarrow gg\gamma$. Mike did this very difficult analysis with only one other colleague, and reported it at conferences, gaining the rare distinction of being invited to lunch by Richard Feynman.

In 1978 Mike joined the emerging effort at LBL on the time projection chamber (TPC) for the PEP-4 experiment at SLAC's PEP storage ring. He led the development of the complex trigger electronics, based on a sophisticated sliding window in the TPC r-z plane to distinguish true event tracks from backgrounds. In addition, he did all the software development for the PDP11/70 that controlled data acquisition. Later, Mike served as experiment spokesperson, championing the physics analysis of several topics and guiding PhD students. More than a hundred publications were completed under Mike's leadership.



Mike Ronan was a strong supporter of the International Linear Collider and TPC effort.

In the era of the SLAC Linear Collider, Mike turned his attention to a particularly challenging aspect of the new accelerator complex – the synchronization of the new and older linac subsystems at gigahertz frequencies, thought by some to be challenging to the point of technical impossibility. Mike served as project engineer with great success, the first non-SLAC individual to hold such responsibility. He later developed a mini-TPC that allowed an early study of backgrounds at BaBar, the PEP-II experiment for the study of b-quarks.

Mike was a strong supporter of the International Linear Collider from the early stages, and was a driving force for an advanced TPC effort. With equal versatility, he built collaborations, developed a suite of fast simulation tools spanning detector performance to physics histograms, and contributed hands-on effort to laboratory studies of the spatial resolution in TPC R&D activities. In recognition of his substantial contributions, he was invited to serve as the American representative for the Global Large Detector effort.

Mike had an uncommon level of enthusiasm, versatility and skill. His sudden and unexpected loss is felt keenly by all of us in the international science community who had the good fortune to work with him.

Lina Galtieri and Dave Nygren, LBNL.

MEETINGS

The **CLIC workshop 2007 (CLIC07)** is on 16–18 October and will take place at CERN. It will provide a forum to review all aspects related to the accelerator, detector and particle physics of a multi-tera electron-volt linear collider based on compact linear collider (CLIC) technology.

For more details contact Hans Braun (Hans.Braun@cern.ch) or Albert De Roeck (deroeck@mail.cern.ch), or see http://project-clic07-workshop.web.cern.ch/project-CLIC07-workshop.

RECRUITMENT

For advertising enquiries, contact *CERN Courier* recruitment/classified, Institute of Physics Publishing, Dirac House, Temple Back, Bristol BS1 6BE, UK.
Tel +44 (0)117 930 1028. Fax +44 (0)117 930 1178. E-mail sales@cerncourier.com.
Rates per single column centimetre: mono $66/€72/£44, single colour $69/€75/£46, full colour $72/€78/£48. Please contact us for more information about publication dates and deadlines.

Deutsches Elektronen-Synchrotron
International Linear Collider

DESY

DESY is one of the leading accelerator centres worldwide. The Laboratory's main research areas comprise a broad program of photon science, including the operation of synchrotron sources and the construction and use of X-ray lasers, and research in elementary particle and astroparticle physics.

The DESY group -FLC- plays a strong role in the worldwide effort to prepare the International Linear Collider (ILC), in the area of hardware development as well as physics and detector studies. We are looking for a

Particle Physicist (Ph.D.)
Reference code: 113/2007

to contribute to the detector optimization for the ILC.
The successful candidate is expected to hold a Ph.D. in experimental particle physics, and preferably experience in data analysis and simulations. He or she should be willing to work in an international context, to supervise students and should have a strong interest in SUSY and its connection to cosmology.
The position is limited to 3 years; an extension up to 5 years in total is possible.

Within this project we are looking for several

Ph.D. Students in Particle Physics
Reference code: 114/2007

Graduate Physicists with the focus on experimental physics are invited to submit their application including a resume and the usual documents.

All positions are embedded in the Collaborative Research Centre 676 „Particles, Strings and the Early Universe" of the DFG. Involvement in ILC hardware development, HERA or LHC data analysis is possible as well. Please send your application to our personnel department quoting the reference code. You may also contact Mrs. Dr. Jenny List (jenny.list@desy.de) for further information.

Salary and benefits are commensurate with those of public service organisations in Germany. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women. DESY has a kindergarten on site.

Deutsches Elektronen-Synchrotron DESY
in the Helmholtz-Gemeinschaft
Notkestraße 85 • 22607 Hamburg • Germany
phone: +49 40/8998-3392 • www.desy.de
email: personal.abteilung@desy.de

Deadline for applications: October 31, 2007

The University of Virginia
Tenure-Track Faculty Position in Experimental High Energy Physics

The Department of Physics of the University of Virginia invites applications for an Assistant Professor tenure-track faculty position in experimental high energy physics starting in Fall semester 2008. Applicants must hold a doctorate in physics and be committed to teaching at both the graduate and undergraduate levels. Prior experience in experimental high energy physics is required. The University of Virginia experimental group has strong participation in the CMS experiment at the Large Hadron Collider and in the NOVA neutrino experiment at Fermilab. Candidates with interests in those experiments will receive special attention. Review of applications will begin on October 2, 2007; full consideration will be extended until December 31, 2007; however, the position remains open to applications until filled.

Interested candidates are to submit a curriculum vitae, a one page (minimum) or two page (maximum) summary of research and teaching interests at **https://jobs.virginia.edu/applicants/Central?quickFind=52261**. Three letters of reference are to be sent directly to phys-hep-exp-pos@virginia.edu (preferably), or to High Energy Physics Search Committee, Department of Physics, University of Virginia, 382 McCormick Road, P.O. Box 400714, Charlottesville, VA 22904-4714, USA

For information on our department, please visit our website at **http://www.physics.virginia.edu**.

The University of Virginia is an equal opportunity/affirmative action employer. Women and members of under-represented minorities are strongly encouraged to apply.

UNIVERSITY *of* VIRGINIA

Project Scientist Position in High Energy Physics Group, University of California, Santa Barbara

The High Energy Physics Group at UC Santa Barbara is seeking an outstanding electrical engineer/scientist to lead UCSB's electronics development effort for upgrades to the silicon tracker of the CMS Experiment at CERN. We are especially interested in candidates who can contribute to the diversity and excellence of the academic community. Candidates must have a Ph.D. degree in electrical engineering or equivalent and proven leadership ability, communication skills, and the ability to successfully mentor graduate students. Familiarity with ASIC design, high-speed front-end electronics, low-level signal processing, and project management in large particle or nuclear physics projects are highly desirable. The appointment may be made at the assistant, associate, or project scientist level, depending on the qualifications of the applicant. Salary will be commensurate with qualifications. Please send a statement of interest and CV in PDF format, as well as the names/contact information of 3 references to Debbie Ceder <**dla@hep.ucsb.edu**> with subject "Project Scientist Application" by November 1, 2007. The position is effective as of January 1, 2008. Further information is available at **http://hep.ucsb.edu**. UCSB is an Equal Opportunity/Affirmative Action Employer.

Indiana University

Senior-Level Faculty Position in Experimental Nuclear Physics

The Department of Physics at Indiana University invites applications for a senior-level faculty position in experimental nuclear physics for an anticipated appointment beginning Fall 2008. We seek an outstanding scientist, an intellectual leader in the field who is interested in joining one of the top nuclear physics groups in the US. A commitment to excellence in teaching at the undergraduate and graduate level is essential. Current research activities of the group include high energy spin physics, hadron structure studies with neutrinos and polarized protons, neutrino oscillation physics, spectroscopy of exotic hadrons, fundamental neutron physics, and several electric dipole moment searches. We expect the successful candidate will expand our research in new directions, and applications from all areas of nuclear physics are welcome. The experimental nuclear physics group is a key part of the Indiana University Cyclotron Facility (IUCF), a multipurpose laboratory which conducts and supports basic research in nuclear physics, nuclear chemistry, accelerator physics, condensed matter and the life sciences.

Interested candidates are encouraged to contact Professor Mike Snow at **snow@iucf.indiana.edu** or **(812)-855-7914**, and to submit a letter of application, current curriculum vitae and arrange for submission of a minimum of six letters of reference to Kathy Hirons at **khirons@indiana.edu** (or by mail to **Professor Mike Snow, Faculty Search, Department of Physics, 727 E. 3rd St., Bloomington, IN, 47405-7105**).

Further information about the IU Physics Department and IUCF can be found at http://www.physics.indiana.edu and http://www.iucf.indiana.edu.

Indiana University is an Affirmative Action, Equal Opportunity Employer committed to excellence through diversity. The University actively encourages applications of women, minorities, and persons with disabilities.

ALBERT-LUDWIGS-UNIVERSITÄT FREIBURG

550 Jahre Albert-Ludwigs-Universität Freiburg 1457 – 2007

The Faculty of Mathematics and Physics of the University of Freiburg / Germany invites applications for a

Professorship in Theoretical Physics (W3)

in the research area of **Quantum Field Theory and Theory of Elementary Particles**. It would be desirable to complement existing activities of the Physics Institute in theoretical and experimental particle physics. The position is available on 1. October 2008.

A prerequisite is the "Habilitation" or an equivalent scientific qualification. The successful applicant is expected to participate in the general teaching, in particular in theoretical physics, and administrative duties of the department. The university is seeking to increase the number of female faculty members and therefore especially encourages suitably qualified women to apply. Applicants with a physical handicap will be given preference over other candidates provided they are equally qualified.

The professorship is available as a permanent position. In case of a first time appointment to professorship, the appointment is, as a rule, temporary, with possible exceptions. The subsequent appointment to a permanent professorship does not require a renewed, full application procedure.

Applications (with a curriculum vitae, copies of degree certificates, list of publications and teaching records) should be sent by December 1st, 2007, to the **Dekan der Fakultät für Mathematik und Physik, Eckerstr. 1, D-79104 Freiburg, Germany.**

Deutsches Elektronen-Synchrotron
in the Helmholtz Association

DESY

DESY is one of the leading accelerator centres worldwide. The Laboratory's main research areas comprise a broad programme of photon science, including the operation of synchrotron sources and the construction and use of X-ray lasers, and research in elementary particle physics. Research at DESY relies on the interplay between photon science, particle physics and accelerator physics. 3000 researchers from around the world use the accelerator-based facilities at DESY.

DESY is seeking the

Chair of the Board of Directors
(successor to Prof. Albrecht Wagner)

The activities of DESY in photon science include the operation of the synchrotron radiation source DORIS III, the hard X-ray source PETRA III (available for users in 2009), and the Free-Electron Laser user facility FLASH providing VUV and soft X-rays. DESY is strongly involved in the European XFEL facility for hard X-rays and hosts the Centre for FEL Science.

The activities of DESY in particle physics include a physics programme related to HERA, participation in the ATLAS and CMS experiments at the Large Hadron Collider, strong involvement in the International Linear Collider project as well as theoretical particle physics and cosmology. In astroparticle physics DESY is participating in the field of neutrino astrophysics with the Icecube experiment.

The activities in accelerator science and technology development focus on superconducting RF technology, the operation of synchrotron light sources, the development and operation of Linac driven light sources (FLASH, XFEL), and the International Linear Collider development.

The Chair of the Board of Directors is the scientific representative of DESY and chairs the Directorate, consisting of the directors for research in particle physics and research with photons, the director of accelerators and the director of administration. He or she carries the overall responsibility for the strategy of the laboratory and its research programmes, their scientific and technical goals, the resource planning and the relation with ministries, other research organisations and universities. The Chair of the Board of Directors is responsible for the international contacts of DESY and the collaboration with the other accelerator laboratories in Europe, Asia and North America.

The Chair of the Board of Directors is also responsible for the positioning of DESY in the Helmholtz Association. He or she is expected to take over responsibilities in the Association such as the coordination of the research area ‚structure of matter'.

Outstanding scientists with a strong research record, international stature, and a broad spectrum of interest, ranging from research with photons to particle physics and accelerator science, who are interested in shaping the future of DESY as a major world research laboratory are invited to apply. The applicant's goal must be the strengthening of the excellence of DESY, building on the existing competences. For further information please contact Prof. Reinhold Rückl (Chairman of the Search Committee, rueckl@physik.uni-wuerzburg.de). Applications should be sent to our personnel department.

Salary and benefits are granted on the basis of a full professor (W3) at a German University. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women. DESY has a kindergarten on site.

Deutsches Elektronen-Synchrotron DESY
in the Helmholtz Association
code: 102/2007 • Notkestraße 85 • 22607 Hamburg • Germany
phone: +49 40/8998-3392 • www.desy.de
email: personal.abteilung@desy.de
Deadline for applications: October 31, 2007

THE COCKCROFT INSTITUTE *of* ACCELERATOR SCIENCE AND TECHNOLOGY

http://www.cockcroft.ac.uk/
Keckwick Lane, Daresbury, Warrington WA4 4AD,
Cheshire, United Kingdom

RESEARCH and ACADEMIC OPPORTUNITIES IN ACCELERATOR SCIENCE AND ENGINEERING

The Cockcroft Institute is a new, international, centre, for accelerator science and technology in the UK. Named after the British Nobel laureate, the late Sir John Cockcroft FRS, who is regarded as the pioneer of modern accelerator research, it was officially opened in September 2006 by the then UK Minister of Science Lord Sainsbury. It is a joint venture of the Universities of Liverpool, Manchester and Lancaster, the UK Science and Technology Facilities Council (STFC), and the North West Regional Development Agency (NWDA). Founded as a unique synergy of academia, national laboratory, and industry, the Institute is located in a purpose-built building housing staff and laboratory equipment next to Daresbury Laboratory and the Daresbury Science and Innovation Centre. Satellite centres are also in place at each university, enabling additional exploitation of cross-disciplinary expertise. The research excellence of the three stake-holding universities has grown from the birth of nuclear and particle physics in 1907 in Manchester, and the subsequent pioneering development of phase-synchronous accelerators in Liverpool in the 1930s, to now encompass research using particle accelerators in High Energy and Nuclear Physics, and in Photon and Neutron Science, at cutting-edge centres worldwide.

The Institute's aim is to provide the intellectual focus, the educational infrastructure, and the scientific and technological facilities for research in particle and photon beams using accelerators and lasers. Its mission is driven by the advancement and exploitation of knowledge for the development of innovative techniques and their application in particle/nuclear, synchrotron radiation and medical science and technology. Examples include non-linear dynamics of charged particle transport, microwaves and superconductivity, novel accelerating structures including photonic band-gap materials, innovative power sources such as Inductive Output Tubes and Multi-beam Klystrons, laser-plasma-beam interactions, principles of efficient energy recovery and exchange between particles and waves, and ultra-fast techniques at the femto-, and even atto-, second frontier. In pursuing such R&D, scientists and engineers are enabled to take major roles in the conception, design, construction, commissioning and operation of major accelerator facilities worldwide.

The R&D programme in the Institute already includes growing involvement in the Large Hadron Collider and its future luminosity upgrade, the International Linear Collider, a Muon Collider and a Neutrino Factory, high intensity neutron spallation technology, a SuperB factory, unstable isotope beams (HIE-ISOLDE and FAIR), non-scaling FFAG technology, and next-generation light sources such as FLASH, XFEL and 4GLS (underway at Daresbury). Staff in the Institute initiated, and now share responsibility for, the completion and exploitation on site of the Energy Recovery Linac Prototype (ERLP). The construction of an electron FFAG prototype (EMMA) is also well advanced. Advanced laser-plasma and FEL research is underway at collaborative institutions. The Institute houses state-of-the-art vacuum, RF, and laser laboratories, which underpin the activities of all research groups. A substantial theory group is engaged in new approaches to the application of electrodynamics to particle accelerator and delivery systems necessitated by the immense challenges of the future. As the expertise and number of staff grow, new initiatives, for example developments for new ring-ring and linac-ring colliders such as a Large Hadron *e*lectron Collider (LH*e*C), and for high gradient, two-beam, acceleration such as CLIC at CERN, are in discussion. Present work of staff involves collaboration with CERN, DESY, BINP, SINP, KEK, BEPC, JLab, LLNL, FNAL, BNL, LBNL, SLAC, ANL, RAL and DL.

The Cockcroft Institute is seeking highly motivated and interested individuals to join the Institute and shape its future as junior and senior faculty members in one of the stake-holder universities. These positions include the possibility of joint appointments with the STFC and its Accelerator Science and Technology Centre (ASTeC). Appointments will be made at Lecturer, Reader and Professor levels, commensurate with expertise and experience, with globally competitive salaries, and with benefits packages in accordance with the established Human Resources policies of the employer. In this instance appointments to six faculty positions are sought, comprising two in association with the University of Liverpool, one each in association with the Universities of Manchester and Lancaster, and two jointly with STFC.

To register early interest and to discuss further details, please contact directly the Director, Prof. Swapan Chattopadhyay (swapan@cockcroft.ac.uk; phone +44 (0)1925 603242). Those interested in making applications are asked to send a complete resume, with a full list of publications and names/addresses of three references (in full confidence) to the Cockcroft Institute Operations Manager, Ms. Liz Mason (e.a.mason@dl.ac.uk; phone +44 1925 603156, fax +44 1925 864303) before December 31, 2007 at the Institute address above. These positions will also be advertised by the individual universities to which formal application must be made, and for which, following initial discussion from the Director, guidance can be given. All positions are expected to be filled by June, 2008.

UNIVERSITY OF LIVERPOOL — MANCHESTER 1824 The University of Manchester — LANCASTER UNIVERSITY — Science & Technology Facilities Council — Northwest REGIONAL DEVELOPMENT AGENCY

PHYSICS AT THE TERA SCALE
Helmholtz Alliance

The Strategic Helmholtz Alliance “Physics at the Terascale” (http://www.terascale.de) is a research network supported by the Helmholtz Associaction and comprises the research centres DESY and FZ Karlsruhe, 17 German universities, and the Max-Planck Institute for Physics. In the framework of the worldwide endeavour of studying the foundations of matter using accerelators with highest energies, the Alliance will bundle the expertise of the participating institutes and support a sustainable development.

As part of the alliance the “Virtual Institute for Detector Technologies (VLDT)” will be created by a number of universities and DESY and will provide basic detector development support, and in particular facilities for the development of complex front end electronics and semi-conductor detectors. Within the VLDT the following positions for engineers and technical physicists are available.

---

universitätbonn

The University of Bonn plans to develop a facility for detector instrumentation and associated front end electronics. The facility will serve research projects both from partners within the Helmholtz Alliance and the Institute of Physics. The University has openings for

Physicist (Ph.D.) (A13 / A14)

to head this laboratory. He/She should have several years of experience in the development of particle physics detectors and instrumentation as well as in electronics. We expect leadership ability and experience in the management of highly collaborative projects for the LHC and ILC detectors. Applicants should also be interested in training students and visiting researchers; and a

Physicist / IC designer (E13)

We are searching for IC designers with several years experience in analogue and digital design of ASIC chips and their application. Applicants must have expert knowledge in IC design tools (CADENCE, SPECTRE, VERILOG or similar) and practical experience in chip testing. For details about these job opportunities please contact wermes@uni-bonn.de or desch@physik.uni-bonn.de

---

DESY

The Helmhotz Centre DESY will provide general detector development support services to members of the Helmholtz Alliance in the area of detectorengineering and test beam support. To strengthen its team DESY has openings for

Two Physicist / Engineer (E12 / E13)

We are seeking candidates with a strong interest and background in detector design and detector building. The persons should become key members of a team at DESY in the context of the Helmholtz Alliance to support detector development for future projects in high energy physics (sLHC and ILC). They should have knowledge in mechanical engineering and/or electronics engineering, and modern CAD systems. Ideally they should be interested to work within large international projects. We welcome applications by engineers as well as by technically oriented physicists. Willingness to travel and to spend longer periods away from DESY will be required. The positions are initially limited to three years. For details about these job opportunities contact Ties.Behnke@desy.de

---

UH Universität Hamburg

The University Hamburg will provide support for Alliance members to study the radiation properties of detector materials. The University has an opening for a

Physicist (E13 TV-L)

to support the activities of the Helmholtz Alliance at Hamburg. The candidate will work primarily on the development of radiation hard silicon for sensors to be used for particle physics (sLHC and ILC) and photon research. The work includes support for irradiation campaigns (hadrons, electrons and photons) for novel silicon materials, material characterisation, the study of microscopic radiation damage, defect kinetics and their relation to macroscopic damage parameters. For details about these job opportunities please contact Robert.Klanner@desy.de at the Detector Laboratory of the Institute for Experimental Physics, Hamburg University.

The Heidelberg ASIC Laboratory located in the Kirchhoff-Institut für Physik at the Ruprecht-Karls-Universität Heidelberg will extend its scope to support scientists and Ph.D. students in the area of analogue and mixed-signal VLSI component and system design and test. The institute has openings for

Two Physicists / Engineers

for the design of integrated microelectronics, in particular analogue and mixed-signal circuits. An excellent knowledge of state-of-the art design- and simulation tools is required; and for the design and test of complex electronic circuits employing ASICs and FPGAs. Practical experience in electronic circuit design and construction is required. Both positions are located in the existing ASIC laboratory for microelectronics. They are immediately available and will be limited until 30.6.2012. For details about these job opportunities please contact meierk@kip.uni-heidelberg.de

---

Universität Karlsruhe (TH)
Research University · founded 1825

The University of Karlsruhe will setup a service facility at the “Institut für experimentelle Kernphysik” enabling irradiation studies of prototype detectors. The institute has an opening for a

Physicist (Ph.D.)

Required is experience with the development, construction and operation of particle detectors with high spatial resolution for High Energy Physics experiments. The successful candidate will setup and lead the service facility as part of the Helmholtz Alliance. The irradiation programme is part of an R/D activity to develop detectors for the sLHC and ILC and uses as facilities the Cyclotron at the Forschungszentrum Karlsruhe and the X-Ray station of the institute. The position is vacant and initially limited to June 30, 2009. For details about these job opportunities please contact mullerth@ekp.uni-karlsruhe.de

---

The full text of the advertisements is available under http://www.terascale.de or by contacting the addresses given above. Applications with the normal supporting documents should be directed to the universities and research centres where the individual jobs are located.

STANFORD UNIVERSITY

STANFORD LINEAR ACCELERATOR CENTER
FACULTY POSITION – PARTICLE PHYSICS EXPERIMENTALIST

The Stanford Linear Accelerator Center (SLAC) invites applications for an appointment of a tenure-track assistant professor in experimental particle physics. We seek candidates with significant accomplishments and promise for future achievement. The successful candidate is expected to play a key role in the energy frontier particle physics program at SLAC, with emphasis on the ATLAS experiment at the LHC for the near term and the buildup of an experiment at the ILC for the future.

Candidates should submit a curriculum vitae, publication list, a statement of research plans and have three letters of reference sent to: Experimental particle physics search committee, c/o PPA Faculty Affairs, MS 60, Stanford Linear Accelerator Center, 2575 Sand Hill Road, Menlo Park, CA 94025, USA or (**ppa_facultyaffairs@slac.stanford.edu**).

Review of applications begins November 16, 2007, though later applicants may be considered. Electronic applications are preferred. SLAC is an equal opportunity employer and is committed to increasing the diversity of its faculty. It welcomes nominations of and applications from women and members of minority groups, as well as others who would bring additional dimensions to the research and teaching missions.

Assistant Professor in Thoretical Particle Physics (Phenomenology)
Illinois Institute of Technology

The Physics Division at Illinois Institute of Technology is seeking applications for a tenure track position in theoretical particle physics (phenomenology) at the level of Assistant Professor starting August 2008. The successful candidate will be provided with a competitive start-up package and laboratory space, and will be expected to establish an innovative, externally funded research program and to excel at teaching in both our undergraduate and graduate programs. For full consideration, submit a curriculum vitae, a summary of research plans, and a statement of teaching interests and philosophies, and arrange for three letters of recommendation to be sent to Prof. Carlo Segre, Chair, Physics Search Committee, physics_search@bcps.iit.edu. The deadline for applications is December 15, 2007.

Illinois Institute of Technology is an equal opportunity, affirmative action employer. Women and minorities are strongly encouraged to apply.

Swansea University
Prifysgol Abertawe

PhD Research Studentship
EXPERIMENTAL ANTIMATTER PHYSICS
Physics Department, Swansea University

A Ph.D. project on antihydrogen is on offer in the Fundamental Atomic Physics group. The group plays a leading role in the ALPHA antihydrogen experiment at CERN in Geneva, Switzerland.

The aim of this experiment is to trap cold antihydrogen in preparation for precision comparisons of hydrogen and antihydrogen. The student will spend most of his/her time at CERN. The experiment involves many subfields of physics and offers many opportunities for the engaged, independent student. The student will work on the plasma physics aspects of the antihydrogen formation. Using rotating electric fields it is possible to control the size and density of the positron and electron plasmas used as well as, possibly, the antiprotons. The aim of this project is to study how the parameters of the plasmas influence the formation of antihydrogen, and how this influences the trapping efficiency.

The studentship will pay home/EU fees + an enhanced bursary of £20,000 p.a. Starting date is as soon as can be arranged.

Enquiries are invited from those with an outstanding academic record. Experience in experimental physics will be an advantage. Send CV or contact: Dr. Niels Madsen, N.Madsen@swan.ac.uk.

University of Heidelberg

Heidelberg Graduate School of Fundamental Physics

The Heidelberg Graduate School of Fundamental Physics (HGSFP) at the University of Heidelberg, established in the framework of the Excellence Initiative of the German Federal and State Governments, invites applications for

Doctoral Scholarships

in its core areas of modern fundamental physics: (a) Particle Physics and Cosmology, (b) Astronomy and Cosmic Physics and (c) Quantum Dynamics and Complex Quantum Systems. The HGSFP combines doctoral projects at the forefront of international research in the areas mentioned above with a rich and thorough teaching program. Further information can be found on the School's web site: http://www.fundamental-physics.uni-hd.de.

Membership in one of the two International Max Planck Research Schools (IMPRS) for Astronomy & Cosmic Physics (http://www.mpia.de/imprs-hd) or for Quantum Dynamics in Physics, Chemistry and Biology (http://www.mpi-hd.mpg.de/imprs-qd) is envisaged if appropriate.

We invite highly qualified and motivated national and international students to apply. Applicants should hold a Master of Science or equivalent degree in physics. At equal level of qualification, preference will be given to disabled candidates. Female students are particularly encouraged to apply.

Applications for scholarships should arrive by **December 13, 2007**. Applicants have to initiate their application registering via a web form available at http://www.fundamental-physics.uni-hd.de/scholarships.php.

LMU | LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN | FACULTY OF PHYSICS

The **Faculty of Physics** at the Ludwig-Maximilian-University Munich invites applications for a

Full Professor Position (W3)

in the field of

Theoretical High Energy Physics

– Succession Prof. Fritzsch –

The main field of research shall be the phenomenology of high energy physics and, in particular, new physics beyond the Standard Model of particle physics. Here a close connection with the physics of the LHC at CERN and with the particle and astroparticle physics of the early universe should be visible. Active participation in the teaching program of the department is required, and also participation in the new Cluster of Excellence "*Origin and Structure of the Universe*", recently been installed at the Campus Garching within the Excellence Initiative of the Federal Government of Germany, is desired.

We are seeking candidates, who are internationally recognized researchers in the fields described above. The possible candidates must not be older than 52 years at the time of the appointment. In urgent cases exceptions can be permitted.

Prerequisites for employment are a university grade, pedagogical suitability. Ph.D. or doctoral degree and additional scientific qualification which can be proved by a habilitation or equivalent achievements.

The Ludwig-Maximilian-University aims at raising the proportion of women in research and teaching and therefore explicitly requests female scientists to apply.

Please, send your application including the usual materials (CV, list of publications, certificates of university degrees) before **10th November 2007** to the **Dekan der Fakultät für Physik, Ludwig-Maximilians-Universität, Schellingstr. 4, 80799 München, Germany**.

Research Positions
LIGO Laboratory

California Institute of Technology (Caltech)
Massachusetts Institute of Technology (MIT)

The Laser Interferometer Gravitational-Wave Observatory (LIGO) has as its goal the development of gravitational wave astronomy. The LIGO Laboratory is managed by Caltech and MIT, and is sponsored by the National Science Foundation. It has built and now operates facilities equipped with laser interferometric detectors at Hanford, Washington and Livingston, Louisiana. The detectors have achieved design sensitivity and a data set spanning more than a year of coincidence operation has been collected. Analysis is ongoing, with extensive participation by the LIGO Scientific Collaboration (LSC). Further observation will be interleaved with incremental improvement of the instruments over the coming years, with a major upgrade (Advanced LIGO) in preparation. In addition, a vigorous R&D program supports the development of enhancements to the detectors as well as future capabilities.

The LIGO Laboratory expects to have positions at Caltech, MIT and at the two observatory sites. Scientists will be involved in the operation of LIGO itself, analysis of data, both for diagnostic purposes and astrophysics searches, as well as the R&D program for future detector improvements. Expertise related to astrophysics, modeling, data analysis, electronics, laser optics, vibration isolation and control systems is useful. Most importantly, candidates should be broadly trained physicists, willing to learn new experimental and analytical techniques, and ready to share in the excitement of building, operating and observing with a gravitational-wave observatory. In general, appointments will be at the post-doctoral level with one-year initial appointments with the possibility of renewal for up to two subsequent years. In some cases, appointments with an initial term of three years or of an indefinite term may be considered. Appointment is contingent upon completion of all requirements for a Ph.D.

Applications for positions at any LIGO Laboratory site (Caltech, MIT, Hanford, or Livingston) should be sent to HR@ligo.caltec.edu (Electronic Portable Document Format (PDF) submittals are preferred). OR mailed to either:

Dr. Jay Marx, c/o Cindy Akutagawa
Caltech
1200 E. California Blvd
LIGO 18-34
Pasadena, CA 91125

OR

Dr. David Shoemaker
MIT
185 Albany St
LIGO NW22-295
Cambridge, MA 02139

Applications should include curriculum vitae, list of publications and the names, addresses, email addresses and telephone numbers of three or more references. Applicants should request that three or more letters of recommendations be sent directly to HR@ligo.caltec.edu (Electronic Portable Document Format (PDF) submittals are preferred) or mailed to Dr. Marx or Dr. Shoemaker. Consideration of applications will begin December 1, 2007 and will continue until all positions have been filled.

Caltech and MIT are Affirmative Action/Equal Opportunity Employers
Women, Minorities, Veterans and Disabled Persons are encouraged to apply

More information about LIGO available at www.ligo.caltech.edu

Joint Position in Experimental Particle Physics:

Assistant Professor at the University of Illinois at Chicago and Associate Scientist at Fermi National Accelerator Laboratory

The Department of Physics at the University of Illinois at Chicago (UIC) and Fermi National Accelerator Laboratory (Fermilab) invite applications for a joint position at the level of Assistant Professor (tenure track) and Associate Scientist respectively, in the area of experimental high-energy particle physics. The position is equally shared between the two institutions with a commensurate reduction in the UIC teaching load. Applicants should have a Ph.D. in physics and have demonstrated an outstanding record of research accomplishments. The successful candidate is expected to establish an externally-funded research program and play a leadership role in the CMS experiment. A strong commitment to teaching at both the undergraduate and graduate levels along with participation in the activities and responsibilities of both institutions are also expected.

Candidates should submit a letter of application, curriculum vitae, list of publications, and a statement of research interests and plans, and should arrange for at least three letters of recommendation to be sent to the address below:

Prof. Nikos Varelas, Search Committee Chair,
c/o Stephanie Clarke
University of Illinois at Chicago
Department of Physics
845 W. Taylor St., M/C 273
Chicago, IL 60607

To ensure full consideration, all information should be received by December 1, 2007.

UIC and Fermilab are Equal Opportunity/Affirmative Action Employers, and applications from women and minority scholars are strongly encouraged.

INDIANA UNIVERSITY

Junior Faculty Position in Theoretical Physics

The Department of Physics at Indiana University invites applications for a tenure-track Assistant Professor position in Theoretical High Energy and/or Theoretical Nuclear Physics for an anticipated appointment beginning Fall 2008. We are seeking highly qualified candidates who will complement or expand upon current research activities of the High Energy Theory and/or Nuclear Theory group focused particularly on any aspect of sub-nuclear physics, astro-particle physics or nuclear astrophysics. The current research directions include nuclear and astro-particle physics, beyond standard model phenomenology, tests of Lorentz and CPT symmetry, lattice QCD and hadron phenomenology and nuclear structure.

Applicants should have a Ph.D., an outstanding research record and commitment to excellence in teaching at both undergraduate and graduate level. The Indiana University Physics Department currently has 37 faculty carrying out research in Accelerator Physics, Experimental Nuclear and High Energy Physics, Condensed Matter and Material Science, and Biophysics.

Applications should be submitted via email to **physsrch@indiana.edu** or by mail to:

Theoretical Physics Search, Physics Department,
Indiana University, Bloomington, IN 47405

Interested applicants should submit a letter of application and curriculum vitae with list of publications, a description of research interests, and arrange for submission of a minimum of three letters of reference. Review of applications will begin on January 15, 2008 and will continue until the position is filled. Further information about the IU physics department can be found at http://www.physics.indiana.edu.

Indiana University is an Affirmative Action, Equal Opportunity Employer committed to excellence through diversity. The University actively encourages applications of women, minorities, and persons with disabilities.

Max Planck Institute for Physics

(Werner Heisenberg Institute)

MAX-PLANCK-GESELLSCHAFT

The Max-Planck-Institute for Physics and the Excellence Cluster "Origin and Structure of the Universe" invite applications for a

Postdoctoral position

in the newly established Junior Research Group on Detector Development in Particle Physics. The Cluster of Excellence has recently been installed on the Garching Campus as part of the Excellence Initiative of the federal government of Germany. The Junior Research Group focuses on research and development on hadronic calorimetry for future experiments, e.g., at the International Linear Collider. The group will study gaseous detectors for a finely segmented digital hadronic calorimeter and will contribute to the development of particle flow algorithms for an optimized jet reconstruction. Detector simulations will also play a crucial role in the evaluation of different calorimeter concepts.

The Junior Research Group also plans to participate in data analysis of high energy polarized proton-proton collisions within the spin physics program of the STAR experiment at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory. Here jet and di-jet production is used to gain information about the spin structure of the proton, in particular the contribution of the gluons to the proton spin.

Applicants should hold a Ph.D. in high-energy physics or a related field and should have a strong interest in detector development and data analysis. Programming skills (C++, ROOT) and an interest in detector simulations (GEANT4) are expected.

Salary and benefits are commensurate with public service organizations (TVöD Bund). The contract is initially limited to 2 years with the possibility of an extension. The Max Planck Society is an equal opportunity employer. The goal is to enhance the percentage of women where they are underrepresented. Women, therefore, are especially encouraged to apply. The federal government of Germany is committed to employing more handicapped people, and applications from handicapped people are particularly welcome.

Interested candidates should apply online at http://www.universe-cluster.de/ and arrange for at least two letters of reference to be sent to:

Max-Planck-Institut für Physik
Frau F. Rudert
Föhringer Ring 6, D-80805 München

Further information can be obtained from Dr. Frank Simon (EMail: fsimon@mit.edu). Applications should be received by October 31, 2007.

Deutsches Elektronen-Synchrotron
Particle and Accelerator Physics

DESY

DESY is one of the leading accelerator centres worldwide. The Laboratory's main research areas comprise a broad program of photon science, including the operation of synchrotron sources and the construction and use of X-ray lasers, and research in elementary particle and astroparticle physics.

For analysis of HERA data, the experiments ATLAS and CMS at LHC, and for the preparations of the International Linear Collider ILC (accelerator and experiments) several

DESY Fellowships

at Hamburg and Zeuthen are announced. Scientists who have completed their Ph.D. within the last 4 years are invited to submit their application including a resume and the usual documents (curriculum vitae, list of publications and copies of university degree). They should arrange for three letters of recommendation to be sent to the personnel department of DESY.
The DESY Fellowships are awarded for a duration of 2 years with the possibility for prolongation by one additional year.

Salary and benefits are commensurate with those of public service organisations in Germany. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women. DESY has a kindergarten on site.

Deutsches Elektronen-Synchrotron DESY
in the Helmholtz Association
code: 115/2007 • Notkestraße 85 • 22607 Hamburg • Germany
phone: +49 40/8998-3392 • www.desy.de
email: personal.abteilung@desy.de

Deadline for applications: October 31, 2007

INDEX TO ADVERTISERS

BOOKSHELF

Books received

Fundamental Physics for Probing and Imaging by Wade Allison, Oxford University Press. Hardback ISBN 9780199203888, £49.95 ($98.50). Paperback ISBN 9780199203895 £24.95 ($49.50).

This book is for every physicist who has ever needed to answer the question: what is physics for? Physics has reduced fear and increased safety for society, largely by extending the power to see. The methods used are magnetic resonance, ionizing radiation and sound, with their extensions. The author follows how they are applied by modern technology to "seeing" in clinical medicine, including therapy, and in other spheres of human activity such as archaeology, geophysics, security and navigation. By taking a broad view of the entire field, the book encourages comparisons and underlines the importance of public education. Physics undergraduates and graduates, as well as professional physicists, will find this book of interest.

An Introduction to the Standard Model of Particle Physics (2nd edition) by W N Cottingham and D A Greenwood, Cambridge University Press. Hardback ISBN 9780521852494 £30 ($65).

The new edition of this introductory graduate textbook provides a concise but accessible introduction to the Standard Model. It has been updated to account for the successes of the theory of strong interactions and the observations on matter–antimatter asymmetry, and includes a coherent presentation of the phenomena of neutrinos with mass and the theory that describes them. The book clearly develops theoretical concepts, from the electromagnetic and weak interactions of leptons and quarks to the strong interactions of quarks. The mathematical treatments are suitable for graduates in physics, and the text and appendices develop more sophisticated mathematical ideas.

Advanced Quantum Theory (3rd edition) by Michael D Scadron, World Scientific Publishing. Hardback ISBN 9789812700506 £51 ($88).

This book looks at the techniques that are used in theoretical elementary-particle physics that are extended to other branches of modern physics. The initial application is to non-relativistic scattering graphs encountered in atomic, solid-state and nuclear physics. Then, focusing on relativistic Feynman diagrams and their construction in lowest order, the book also covers relativistic quantum theory based on group theoretical language, scattering theory and finite parts of higher order graphs. Aimed at students and professors of physics, it should also aid the non-specialist in mastering the principles and calculation tools that probe the quantum nature of the fundamental forces.

Conceptions of Cosmos. From Myths to the Accelerating Universe: A History of Cosmology by Helge S Kragh, Oxford University Press. Hardback ISBN 9780199209163 £35 ($100).

This is a historical account of how natural philosophers and scientists have endeavoured to understand the universe at large, first in a mythical and later in a scientific context. Starting with the creation stories of ancient Egypt and Mesopotamia, the book covers all of the major events in theoretical and observational cosmology, from Aristotle's cosmos through the Copernican revolution to the discovery of the accelerating universe in the late 1990s. It presents cosmology as a subject including scientific as well as non-scientific dimensions, and tells the story of how it developed into a true science of the heavens. It also offers an integrated account with emphasis on the modern Einsteinian and post-Einsteinian period. This book is suitable for students and professionals in astronomy, physics and history of science.

Statistical Methods in Experimental Physics (2nd edition) by Frederick James, World Scientific Publishing. Hardback ISBN 9789812567956 £33 ($58). Paperback ISBN 9789812705273 £17 ($30).

In this second edition many chapters now include considerable new material, especially in areas concerning the theory and practice of confidence intervals, including the important Feldman–Cousins method. Both frequentist and Bayesian methodologies are presented, with a strong emphasis on techniques that are useful to physicists and other scientists in the interpretation of experimental data and comparison with scientific theories. This textbook is suitable for advanced graduate students in the physical sciences, as well as a reference for active researchers.

It's Physikshow time in Germany

Particle theorist **Herbi Dreiner** describes how the Physikshow by students in Bonn is working to build the next generation of good science communicators.

We are in Munich, in the Deutsches Museum's Ehrensaal – a hall of fame of German science and engineering. Busts of Kepler, Gauss, Einstein, Meitner, and many others gaze down on us. We are: 18 physics students from Bonn University; Michael Kortmann, who is in charge of our demonstration experiments; and myself. The students are here to put on a 90 minute physics show to a sold-out audience of about 300 people. The doors will open shortly. Our host, Rainer Mählmann, is pretty nervous. At dinner later he confesses that he didn't sleep well. It's understandable – the two days of rehearsals were loads of fun, but very chaotic. I am excited and confident.

The idea for the show began when I was a graduate student in Madison, Wisconsin, in 1984–89. Prof. Clint Sprott regularly presented the Wonders of Physics, a fun show for children aged 12 and older. Six years ago, I decided to launch a similar activity in Bonn, with the difference that the students should prepare and present the show themselves. I approached the class of second-year students that I was teaching and immediately had 25 volunteers. Michael Kortmann introduced them to our extensive collection of demonstration experiments and gave them a relatively free rein. This, it turns out, is heaven on earth for a young physicist.

Over the coming months, we had several meetings discussing possible experiments and forms of presentation. Meanwhile, I gradually withdrew from the organization and development of the show and handed it over to the students. This was partly by design and partly down to a lack of time on my part. The students gladly took on the responsibility and created their show – the Physikshow. They could thus fully identify with it and they subsequently put in a tremendous amount of time and energy. I recall once being in a neighbouring room and hearing them discuss how to explain to 10-year-olds an experiment on electromagnetism involving Lenz's rule.

The Physikshow student team gather in the Ehrensaal of the Deutsches Museum in Munich, under the watchful eye of Gottfried Leibnitz. (Courtesy Michael Kortmann.)

(In the experiment, the frozen metal ring jumps 6 m into the air.) For the students the show is a great opportunity to apply their new knowledge for the first time and outside of the restrictions of regular coursework. They are in it for the fun and the glory, and of course the great barbecue parties.

The students have developed ideas that I would never have thought of, both for the general presentation of the show and for new experiments. For example, most of the experiments are accompanied by upbeat music. This completely transforms even simple experiments. Furthermore, the various physics topics (mechanics, electromagnetism, atomic physics, etc.) are introduced by short self-made films, which are shown on a large screen. For example, a mechanics film shows a Newton's pendulum, and then switches to films of car crash tests, both accompanied by Beethoven's 9th (and now available on *YouTube* at www.youtube.com/watch?v=vtj6Th6wb8g). For the students, it is also easy to address the children at the right level. Many of them have younger siblings or have led youth groups. The students' enthusiasm and dedication then naturally carries over to the children in the audience.

A simple experiment the students came up with was to put a pickle between two forks and apply 220 V. Owing to the salt in the pickle there is a current and a discharge: the pickle starts glowing, which is easily visible in a dark lecture hall. You can also do this with pears or other fruit. (The German word for light bulb is *Glühbirne*, or "glowing pear".) Another experiment involves a large wooden box, of about 3 cubic metres, with an 80 cm diameter hole in the middle of the front, and the back covered with a thick foil. If you fill the box with smoke and bang the back, a 1 m diameter smoke ring ejects from the front, and can easily travel 20 m across a room. One experiment, with a ship floating on nothing, has even become a hit on *YouTube*, with half a million viewings (see www.youtube.com/watch?v=1PJTq2xQiQ0).

The shows have become a huge success with the public. Every year for the past five years, a new group of second-year students has expertly presented a new two-hour show for children, with six performances a year and a full auditorium (550 seats). We now have a large pool of students with experience in publicly presenting science. This has enabled us to tackle new challenges with the experienced students, for example the Bonn University Science Night, or a show on particle physics for the launch of the LHC. However, despite delegating much of the work to the students, it is starting to take over my life.

Back in Munich, the students will soon have the Ehrensaal rocking. They have become complete naturals in front of large audiences and thrive on the atmosphere. Light and sound and the short films work perfectly. There are loud bangs and magically floating ships, expanding marshmallows in a vacuum and glowing pickles, and then they make wonderful smoke rings in the back – Bang! – slowly floating across the elegant room, over the heads of the audience, under the chandelier, setting it tinkling, and finally putting a flutter into the stage curtain and a smile onto Rainer Mählmann's face.

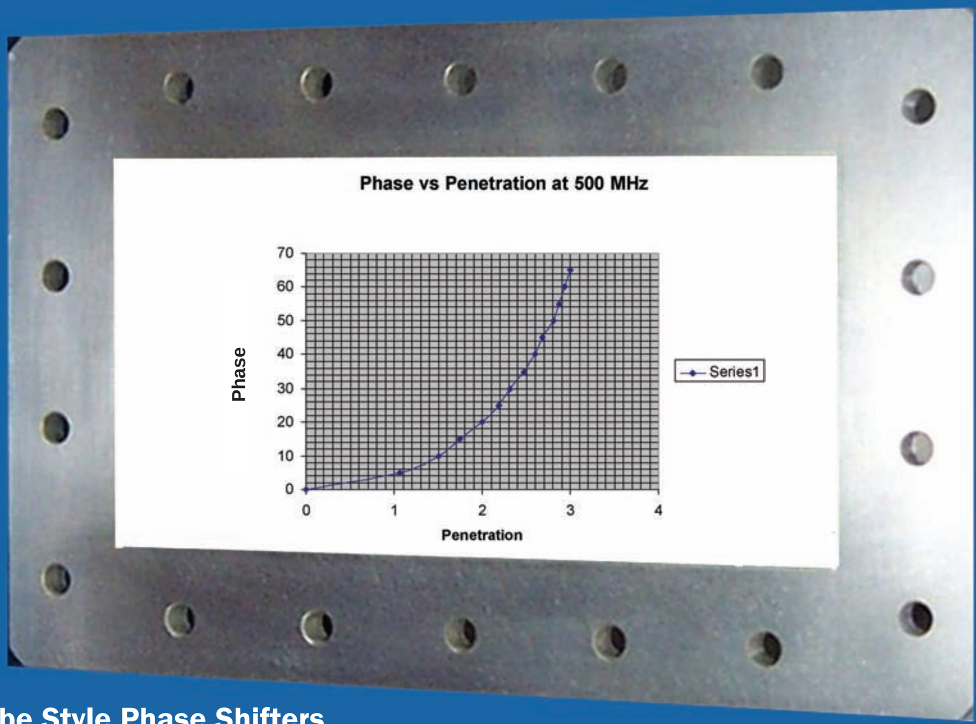
Herbi Dreiner, *University of Bonn.*

MEGA INDUSTRIES, LLC **RF Solutions**

www.megaind.com

Semi-Flexible Waveguide
WR90 through WR2300

High Power De-ionised water loads provide excellent wide bandwidth characteristics



Compact Probe Style Phase Shifters provide up to 45 degrees under a 1.05:1 VSWR

Waveguide Safety Shutter Switches provide reliable Personnel Protection

MEGA Industries LLC is the world's Premier High Power RF Solutions Company. Over 40 years engineering expertise combined with a world class manufacturing facility ensures the highest quality High Power RF components in the world.

28 Sanford Drive, Gorham, ME 04038 Telephone 207-854-1700 Fax 207-854-2287
E-mail: sales@megaind.com Web Site: www.megaind.com